Physical Exploration of the Lungs

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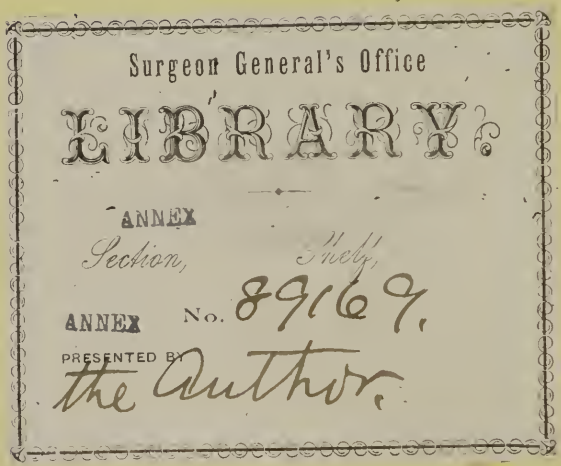

With the Author's regards
March 1883.

PHILADELPHIA COUNTY MEDICAL SOCIETY LECTURES.

PHYSICAL EXPLORATION

OF THE

LUNGS

BY MEANS OF AUSCULTATION AND PERCUSSION.

A COURSE OF THREE LECTURES

DELIVERED BY INVITATION BEFORE THE PHILADELPHIA COUNTY MEDICAL SOCIETY.

BY

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LECTURE I.

Mr. President and Members of the Philadelphia County Medical Society: The invitation to give a few lectures on some subject pertaining to practical medicine was accepted by me with a full appreciation of the high compliment and the responsibility therein involved. I cannot adequately express the gratification which I shall feel if, at the close of the lectures, I may be able to persuade myself that any expectations on your part, beyond the gratification of a complimentary disposition, have been measurably fulfilled. The subject selected, with the approval of the Committee on Lectures, is one to which for many years I have given much attention as a clinical student, and a clinical teacher. It may seem to be a hackneyed subject, but I hope to succeed in showing that it is one which at the present time claims attentive consideration with reference to a further increase, and a more general diffusion of the usefulness of its practical applications in the diagnosis of diseases.

THE TRUE MODE OF STUDY

AND ITS

REQUIREMENTS AS REGARDS AUSCULTATION AND PERCUSSION.

THE SIGNS OBTAINED BY PERCUSSION.[1]

INTRODUCTORY REMARKS.

THE discovery of auscultation by Laennec in 1816, led to the resurrection of percussion as a method of physical exploration, a method brought into existence by Auenbrugger, but which the publication in Latin, in 1761, of the *inventum novum*, failed to keep alive, and which Corvisart, by his translation of Auenbrugger's treatise into the French language with abundant commentaries, published in 1808, had vainly attempted to reanimate. Restored to life by Laennec, percussion has since been hand in hand with auscultation. Each of these two methods has given invaluable aid to the other. They cannot with propriety be disjoined in practice, and they are necessarily associated in treating of the diagnosis of diseases. It would be of little use to discuss the relative advantages of the two methods. Doubtless, were we to be deprived of one of them, we could better afford to lose percussion than auscultation, but the advantages of either would be greatly dimin-

[1] Delivered November 25, 1882.

ished by the loss of the other. A more useful point of inquiry is, What progress has been made in our knowledge of physical exploration by the two methods conjointly since the time of Laennec? In answer to this inquiry, I have no intention to review in detail the labors of those who have cultivated this field in practical medicine since Laennec's day. They occupy a considerable space in the medical literature of the last half century. I shall offer some general statements, by way of introduction to the lectures, to which your attention is invited. The facts in auscultation which Laennec discovered constitute much stronger evidence of his genius than the discovery of the method. The latter, as he relates, was accidental. It is a marvel that he ascertained so much of what is known of auscultatory phenomena at the present time. The medical student of to-day may read his treatise with advantage on account of the accuracy of the observations, as well as affording a model of truth-loving candor and unaffected simplicity. It would have been strange indeed, if, in the interpretation of his observations, he had not fallen into some errors, and had he not failed to recognize all the directions in which the subject affords scope for clinical study. Of the many works which have appeared since the publication of Laennec's treatise, I will mention here but one, namely, the work of Skoda, published in 1839. This work passed through several editions, and was translated into the French and the English language. A considerable portion of the work is devoted to a refutation of Laennec's physical explanations of auscultatory phenomena. The tone of criticism is dogmatical, and it might perhaps be said to be arrogant. The author substitutes his own theories for the explanations given by Laennec, classifies differently the physical signs obtained by auscultation and percussion, and designates their distinctive characters by different terms. I shall refer to this work repeatedly in the course of my lectures, and

oftener with dissent than with concurrence. The work has had a controlling effect upon the views of German medical writers up to the present moment, and, also, not an inconsiderable influence on the views of writers in other countries. I do not hesitate in expressing my belief that thereby auscultation and percussion have been injured as regards progress and the diffusion of knowledge in these branches of practical medicine.

Much as has been acquired by means of these two methods of exploration within the last fifty years, the place which they now hold in medical practice is not, as it seems to me, proportionate to the labor given to them, and the space which they now occupy in medical literature. Many practitioners make but little use of them. They are considered as constituting a specialty. There is lack of unanimity among those who bestow upon them special consideration, or regard the number of physical signs, the characters by which they are designated, and the significance which respectively belongs to them. The want of unanimity in the names used to designate different signs was so apparent in the discussion by the members of the Section in Medicine at the meeting of the International Medical Congress in 1881, that a committee was appointed to report an uniform nomenclature, at the next congress. This committee is composed of representatives from England, France, Germany, and the United States. It remains to be seen what they may accomplish.[1]

Writers are apt to enter largely into theoretic discussions relating to the mechanism of physical signs, discussions which are not essential, often unprofitable, and not infrequently leading to errors of observation.

By some writers signs have been needlessly multiplied, and the subject has been rendered apparently mysterious and abstruse by over-refinements. These

[1] The members of this committee are as follows: Prof. Austin Flint, of New York, Chairman; Prof. Ewald, of Berlin; Prof. D'Espine, of Geneva; Dr. Powell and Dr. Mahommed, of London.

are obstacles which have retarded progress in the knowledge of auscultation and percussion, and limited their practical use by medical practitioners.

THE TRUE MODE OF STUDY AND ITS REQUIREMENTS AS REGARDS AUSCULTATION AND PERCUSSION.

The true mode of study has been overlooked. By adopting and keeping steadily in view the requirements of the true mode of study, as I firmly believe, the obstacles just referred to will be avoided, our knowledge of physical signs will have a degree of precision which will make them far more available in diagnosis than hitherto, and the practice of auscultation and percussion will have a simplicity which should place its advantages in the hands of every intelligent, well-educated practitioner of medicine. What are the requirements for these desirable objects?

Firstly. A recognition of the fact that the signs obtained by means of auscultation and percussion are not directly diagnostic of particular diseases, but that they represent abnormal physical conditions which are common to a greater or less number of different diseases. The sign which approaches nearest to a pathognomonic significance, namely, the crepitant râle, does not exclusively belong to pneumonia. Signs which denote solidification of lung, namely, bronchial and broncho-vesicular respiration, increased vocal resonance, and bronchophony, are incident to various affections. The same is true of other signs. Given the presence of certain signs representing certain abnormal physical conditions in any case of disease, the diagnosis is to be determined by these signs taken in connection with the previous history of the case, and the present symptoms. It would be superfluous here to give illustrations, and I need hardly add, that this first requirement involves, in addition to a practical acquaintance with physical signs, knowledge of the

important abnormal physical conditions which the signs represent, and of the relations of these conditions to the diseases in which they occur.

Secondly. It is to be acknowledged and borne in mind that positive proof of the diagnostic significance of the physical signs, as representing abnormal physical conditions, must be based exclusively on the constancy of the association of the latter with the former. The only solid foundation for practical knowledge of auscultation and percussion, thus, is on the facts obtained by clinical observation and by autopsical examinations, the facts from these two sources being ascertained in conjunction with each other. To establish physical diagnosis purely on the basis of principles of physics, is to build upon a sandy foundation. Not infrequently the conclusions concerning the significance of signs, logically deducted from physical data, are in direct conflict with facts derived from clinical observation. Reasoning *à priori* from the data of physics, the accuracy of observation is apt to be impaired. I would by no means imply that it is not desirable to explain, on the principles of physics, the connection existing between morbid physical conditions and their representative signs, but the diagnostic significance of the latter should in no way be thereby affected. It is useful as a means of corroborating and illustrating the significance of signs, to imitate, by artificial contrivances out of the body, as nearly as practicable, the physical conditions which the signs represent; and I hope to be able to show that the essential characters of nearly all the important signs obtained by auscultation and percussion may be artificially represented. I shall also introduce results of experimental observations which will show that many of the important physical signs may be profitably studied by making use of healthy and diseased lungs removed from the body. Most of the respiratory and vocal signs, as well as those obtained by percussion, may be reproduced after death by artificial respiration

and the transmission into the air tubes of vocal sounds. The study of physical signs in this way is useful, in order to become familiar with their differential characters, and also with reference to the mechanism of their production.

The most unreliable course in forming judgments concerning the existence of certain morbid physical conditions, is to judge from the mental impressions produced by certain sounds, not heeding any well-defined characters of the latter. Here full sway is allowed to the imagination. The auscultator will be likely to find proof of physical conditions, the existence of which he had already inferred from the symptoms. Even Laennec's treatise is open to criticism on this score. Thus, he distinguished cavernous respiration as a sound giving an impression of air passing into a larger space than when the respiration is bronchial; he described pectoriloquy as complete when the voice seems to traverse the whole length of the stethoscope, whereas it traverses it partially when the pectoriloquy is incomplete, and the sign which he called a masked-blowing murmur (*souffle voilé*), was based on the idea of a movable veil between a cavity and the ear of the auscultator.

Thirdly. Individual physical signs are to be recognized as such only when their constant connection with distinct abnormal physical conditions has been established. This requirement is a security against an undue multiplication of signs by individualizing sounds which may be variations of established signs, or the significance of which has not been ascertained.

Fourthly. The differential characters of different signs would be distinct, clear, and simple. This requirement is of special importance as bearing on the true mode in which auscultation and percussion are to be studied. Naturally, the discoverer of auscultation was led to compare the sounds which he heard to those which are familiar. Hence, Laennec compared bronchial

respiration to the sound of a current of air through a tube; ægophony to the cry of the goat; the crepitant râle to the crackling of salt on coals of fire; and the normal respiratory murmur to the sounds from the mouth of a person sleeping and breathing tranquilly. Skoda and others have undertaken to give an idea of auscultatory sounds by imitating them in the pronunciation, with the whispered voice, of different letters of the alphabet. A little reflection must, I think, render it evident that such comparisons cannot supply differential characters of the different signs obtained by either auscultation or percussion with that distinctiveness, clearness, and precision which are essential. There is but one way in which these differential characters can be made clear, distinctive, and precise. This is by means of what I have termed, by way of distinction, the analytical study of the sounds in health and disease. By the analytical study I mean, resolving the sounds into those elementary characters by which all sounds, natural or artificial, musical and non-musical, are practically discriminated. Now the chief differential points by which different sounds are distinguished from each other, relate to intensity, pitch, and quality. The distinctive characters of the sounds obtained by auscultation and percussion should be based mainly on points of difference derived from intensity, pitch, and quality. As thus derived, the differential characters may be made clear, distinct, precise, and also simple. Minor points of difference, which, however, are not to be overlooked, and in some instances are highly important, relate to the duration of sound, the rhythmical succession of inspiratory and expiratory sounds, and the apparent distance from, or nearness to, the ear of the listener. More than thirty years ago, I was led to study the sounds obtained by auscultation and percussion with special reference to their variations in pitch. The results of the study were given in an essay which received a prize from the American Medical As-

sociation, and which was published in the *Transactions* of the Association of 1852.[1] I believe I was correct in commencing the essay by saying that "Very little attention has hitherto been paid to variations in the pitch of sounds heard in the practice of percussion and pulmonary auscultation." Although since that date increased attention has been paid to auscultatory sounds and those obtained by percussion, the distinctions pertaining to this source of differential characters, which were pointed out in that publication, have not, as yet, been fully and generally accepted. I have indicated, since the publication of that essay, additional distinctions which, as it seems to me, are of much importance in their applications to diagnosis. In treating of physical signs, in these lectures, it is but fair to my hearers to state that certain points of distinction relating to the pitch and quality of sounds originated in my own observations, and, on the other hand, it is but right to claim whatever merit may belong to my orignal observations.

Fifthly. The last requirement to be mentioned relates to nomenclature. The names by which the physical signs are designated, and the terms applied to their distinctive characters, should be correctly and clearly expressive. It is, of course, very desirable that the nomenclature should be uniform, as regards words and their meanings, in all countries. Words which denote theoretical views are objectionable. An example is the term "consonating," applied by Skoda to certain sounds produced by the breath, and the voice, and to certain râles. The term denotes not only a theory, but one the correctness of which is maintained by few, if any. The terms "full" and "empty," applied by the same author to sounds produced by percussion, convey no well-defined ideas, and it is not easy to under-

[1] This essay was entitled "On Variations of Pitch in Percussion and Respiratory Sounds, and their Application to Physical Diagnosis."

stand what the author means by them after carefully reading his explanations. These terms are still in use by German authors, as also another singularly unsatisfactory term, namely, "indeterminate." Skoda applies this term to respiratory sounds which are neither bronchial nor vesicular, not attempting to give any positive, distinctive characters, and, indeed, declaring that this is impossible. I hope to show that it is not in the least necessary to use such a negative term as "indeterminate" in designating a group of respiratory signs. Such names as "wooden resonance," and "band-box resonance," are too loose to be appropriate. Especially objectionable is the designation of signs after the names of those who have described them. The names Williams, Skoda, Gerhardt, Biermer, and Wintrick have been introduced into the nomenclature of physical exploration by some German authors.

PERCUSSION.

It is usual to consider percussion before considering auscultation. The compass of the former is much the smaller, and its consideration prepares for that of the latter. Moreover, in the clinical employment of the two methods, percussion generally precedes auscultation.

PERCUSSORS AND PLEXIMETERS.

Auenbrugger was content with percussing by the fingers directly upon the thoracic parietes. The introduction of the plexímeter by Piorry was an improvement, but of vastly less importance than was claimed by him. It has perhaps never occurred to some of those present to practise immediate percussion. It will be found on trial less unsatisfactory, probably, than had been supposed. The credit of using a hammer, instead of the finger, as a percussor, is attributed to Wintrich. The

hammer devised by him, and I believe still used in Germany, is a curiosity. As it has been but little used in this country, it may have interest in the way of novelty to some present, and I therefore exhibit it. As you see, the hammer part of the instrument, which is made of brass, is long and heavy. The point is tipped with India rubber. The handle is light and thin, with excavations to receive the ends of the thumb and fingers. It could hardly have been more clumsily devised to be used by striking directly upon the pleximeter. This was not intended; but the hammer is to be thrown upward by the movement of the hand in which it is held, and then allowed to fall upon the pleximeter. It is difficult to see in what respect this manner of percussing has any advantage over that in which the blows are made directly, and the disadvantages are obvious. It would not be profitable to discuss the different varieties of percussors which are in use with us. I shall simply show one which I have used for many years, and which I have found to answer admirably. It consists of a piece of India rubber in the form of a double cone, held in a ring at the end of a handle made of vulcanized rubber. It is light; it makes but little noise in coming into contact with whatever is used as a pleximeter, and it is durable.

I need not say that as both a pleximeter and a percussor, the fingers of the two hands answer every purpose in private practice. The chief object of an artificial pleximeter is to save the fingers from injury by frequent percussion. The pleximeter which I show I have used for some time. It is made of vulcanized India rubber, is light, easily held, and readily applied to the chest.

THE NORMAL VESICULAR RESONANCE ON PERCUSSION.

A thorough practical knowledge of the characters which distinguish the sounds in health is, of course, essential, as preparatory for the study of the morbid signs furnished by percussion and by auscultation. I have always found it difficult to enforce sufficiently this obvious truth in teaching medical students, and I suspect that with practitioners difficulty in the recognition of morbid signs is often attributable to an imperfect appreciation of the characters distinctive of normal sounds. Studied analytically, the characters which distinguish the normal resonance on percussion are resolvable into those derived from pitch and quality, inasmuch as the intensity varies in different persons and in different regions of the chest. Some exercise is necessary for a correct appreciation of pitch, as distinguished from quality, in the sounds obtained by percussion. Errors are sometimes attributable to a lack of this exercise. The relative variations in pitch are easily expressed by the terms high and low. On the other hand, the peculiar quality of any sound cannot be expressed in language. Let it be supposed, for example, that one should endeavor to describe the quality of the tones of a violin, or of any other musical instrument, to one who had never heard them. An idea of the quality of sounds can only be given by comparison, and it is rare for two sounds produced in different ways to resemble each other so closely that the one will give a clear idea of the other. Moreover, the variations in the quality of sounds are innumerable. As an illustration, let it be considered that the human voice has so many diversities, irrespective of pitch and intensity, that among many thousand persons it would be difficult to find two voices precisely alike. Hence, the peculiar quality of sounds must be learned by direct observation. Now, as regards the pitch and quality of the normal pulmo-

nary resonance, the quality is *sui generis*. It cannot be described. Evidently the quality is dependent on the fact that the air which gives the resonance is contained in the pulmonary vesicles or alveolæ, and not in a free space, and, for this reason, the name *vesicular*, which is used to distinguish this peculiar quality, is appropriate. The pitch, as compared with the abnormal sound obtained by percussion, is low. I believe I am correct in saying that no abnormal sound obtained by percussing the chest is ever lower in pitch than the normal vesicular resonance in the same subject. The pitch of the normal resonance is evidently determined by the same physical conditions to which the vesicular quality is attributable, for the pitch is lower in proportion as this quality is marked, and *vice versa*.

In order to represent, artificially, vesicular resonance, an article must be found which resembles lung in the essential physical condition, namely, containing air in innumerable minute spaces. A feeble imitation is obtained by percussing a sponge. My friend, Dr. J. S. Thatcher, has suggested a much better article—a loaf of bread. Bread in the form of a loaf gives a resonance of considerable intensity, and it is a fair representation of the vesicular resonance. It should be covered with a cloth in order to diminish the noise produced by the contact of the fingers or the percussor, and thus to elicit better the sound from the air contained in the interstices of the loaf. The upper crust stands in place of the thoracic wall. The resonance elicited illustrates the lowness of the pitch, with a pretty close approach to the peculiar quality of the normal pulmonary resonance.

When it is considered that all the knowledge furnished by percussion, which is available in the physical diagnosis of pulmonary diseases, may be comprised in four signs, one is led to exclaim, What is to hinder the possession of this knowledge to the fullest extent by every practitioner! There is no hindrance beyond

unanimity in the recognition of the existence of these signs, and that practical acquaintance with their differential characters which requires but a very moderate amount of time and attention. Arranged in pairs, the four signs are, 1st, flatness and dulness; 2d, tympanitic and vesiculo-tympanitic resonance.

FLATNESS AND DULNESS.

The first pair represent different degrees of the same morbid physical conditions, namely, either the presence of liquid in the pleural cavity, liquid in the vesicles, or in the interstitial lung tissue, or solidification of lung incident to pneumonia, phthisis, pleurisy, and other affections, or morbid growths within or extending into the intra-thoracic space. It is to be understood that the term flatness means no proper sound or resonance. It is absence of sound. It cannot be defined more distinctly than by this statement. There can, of course, be no degrees or variety of flatness.

In dulness, the resonance is more or less diminished. There are degrees varying from the slightest diminution to that approximating as closely as possible to flatness. Flatness has, of course, neither pitch nor quality of sound. Dulness, considered as a distinct sign, always has more or less of the quality which belongs to the normal resonance, that is, the vesicular quality. If this quality be entirely wanting, the resonance is tympanitic, as will presently be seen. A fact which I pointed out in my essay published in 1852, is that in dulness the pitch of sound is invariably higher than that of the normal resonance of the person examined. This fact is of importance, as assisting in the recognition of a slight degree of dulness. It is of much importance in certain cases which will be referred to in connection with vesiculo-tympanitic resonance. The elevation of pitch now generally enters into the account given by medical

writers of dulness or percussion, which it did not prior to 1852.

The essential distinction in the other pair of signs, namely,

TYMPANITIC AND VESICULO-TYMPANITIC RESONANCE,

relates to quality of sound. In a purely tympanitic resonance, there is complete absence of the vesicular quality which belongs to the normal resonance. Conversely, a resonance in which the vesicular quality is absent is always tympanitic. This sign represents the following morbid physical conditions: air in the pleural space, pulmonary cavities, solidification of the upper lobe of a lung, the resonance then being derived from air in the extra-pulmonary bronchial tubes, and conduction of resonance from the stomach or colon.

The tympanitic resonance, as just distinguished, is artificially reproduced whenever resonance is derived from air in a free space of greater or less size, instead of being derived from air in a collection of minute spaces like those of the pulmonary vesicles, or the interstices of the bread-loaf. The intensity of the resonance will depend on the amount of free air, the thickness, elasticity, and tension of the walls of the space containing the air, and other circumstances, aside from the force of the percussion. However feeble and distant, the resonance is always tympanitic if it be devoid of that peculiar quality due to the fact that the air is in minute spaces, namely, the vesicular quality. It is, perhaps, a common impression that for a resonance to be tympanitic, it must be louder than the normal resonance. Intensity is an unimportant element so far as regards the distinctive characters of the sign. It may have any degree of gradation between much intensity and great feebleness of sound. Air in the pleural space frequently yields a tympanitic resonance which is notably intense. As a rule, the resonance is com-

paratively feeble over a pulmonary cavity, and where derived from air in the extra-pulmonary bronchi, the sound being conducted through solidified lung.

A tympanitic resonance is invariably higher in pitch than the normal resonance. I believe this statement to be correct, although the reverse is stated by some medical writers, who are in error, as I suppose, either from reasoning incorrectly on principles of physics, or from not accurately distinguishing pitch from intensity and quality. The latter mistake is liable to occur without some training of the ear, and careful attention. It is by no means as easy to distinguish variations in the pitch of non-musical sounds as of musical notes. Some exercise is requisite to secure accuracy, and the discrimination is undoubtedly somewhat difficult for those who have not what is called a "musical ear."

Other things being equal, the pitch is lowered the larger the free space containing air. The bass-drum has a notably lower tone than the kettle-drum, and the non-musical resonance from an inflated bladder or an India-rubber bag of considerable size, is lower than that from a small hollow India-rubber ball. Percussion over a flatulent cæcum gives a higher pitch of resonance than over the stomach; the pitch of resonance over the colon distended with gas is lower than the resonance from either the stomach or cæcum, and the resonance over the small intestine is still lower. Tension has much to do with pitch; this is shown by the effect of tightening a drum-head. The effect of the difference in the material of the walls of the space enclosing air, upon the pitch and intensity, is shown by comparing the sounds produced by beating a drum on its head and on its sides. The many variations corresponding to those in the physical conditions which give rise to tympanitic resonance, may have interest for some who are curious as regards the *minutiæ* of acoustic phenomena, but, if two varieties to be presently noticed be excepted, the variations in tympanitic resonance are of

no utility in their practical applications to physical diagnosis. They are burdensome and perplexing to the student of percussion who desires only to acquire the knowledge which is practically useful. One who wishes more than this will find in the treatise by Eichhorst on the *Physical Methods of Investigating Internal Diseases*, enough to gratify curiosity respecting minute and superfluous details.

A practical point of importance pertaining to tympanitic resonance, is its ready conduction for a greater or less distance beyond the limits of the space whence it comes. In this respect it differs notably from the normal vesicular resonance. A gastric tympanitic resonance is often conducted upward over a considerable portion of the thorax on the left side. In like manner, the resonance from the colon may extend as far as, or even above, the upper boundary of hepatic flatness. It follows that this resonance is unreliable for determining with accuracy the lower border of the liver, the boundaries of the spleen, and the space occupied by abdominal tumors.

AMPHORIC AND CRACKED-METAL RESONANCE.

Tympanitic resonance, with either an amphoric or cracked-metal intonation, claims but a passing notice. The familiar illustrations of these varieties by filliping the check made more or less tense, and by striking the closed hands upon the knee, cannot be improved upon. The intonations may be produced by percussing India-rubber hollow balls of different sizes. Clinically, the fact that the intonations are sometimes heard on percussing over the solidified upper lobe of the lung in situations over the extra-pulmonary bronchi, is not to be overlooked. And the fact that, with this exception and the rare instances in which in these situations they are found in health, they are invariably cavernous signs, renders them of much value in diagnosis. Another

practical fact is perhaps not always appreciated, namely, that these intonations may very often be perceived by the ear close to the open mouth of the patient, when otherwise they escape observation. Still another fact deserves mention. With the pectoral extremity of the binaural stethoscope close to the open mouth of the patient, they may be recognized when they are not readily perceived without this instrument. Finally, it is to be borne in mind that they are found at some times and not at other times, owing to the varying condition of cavities as regard emptiness, and of the bronchial tubes as regards freedom from obstruction.

The last of the four signs is the

VESICULO-TYMPANITIC RESONANCE.

I must hold myself responsible for the name and the description of the characters distinctive of this sign. The name expresses the most diagnostic feature. The vesicular and the tympanitic quality are combined in varying proportions. An essential feature, however, is an increase in intensity. The intensification may be greater or less in degree. The pitch of the resonance is invariably raised. It is raised in proportion as the tympanitic predominates over the vesicular quality. This sign is therefore distinguished from the normal resonance by the presence of more or less of the tympanitic quality of sound, by greater intensity, and by a higher pitch. It is distinguished from the tympanitic resonance by the presence of more or less of the vesicular quality of sound. It is distinguished from dulness by its intensity. The only difficulty in its recognition practically, pertains to its discrimination from tympanitic resonance. The predominance of the tympanitic quality, with a proportionate elevation of pitch, may be so great that it may seem to be purely tympanitic. This error may always be avoided by attention

to coexisting physical signs. The sign represents an abnormal accumulation of air within the air-cells. It is, therefore, *par excellence*, the sign of pulmonary emphysema. Its practical value in diagnosis is chiefly in that pathological connection. It occurs, however, in other pathological connections. It is this sign which is obtained above the level of liquid when the quantity is sufficient to fill a third, a half, or even two-thirds of the thoracic space, be the liquid either serous or purulent. It is obtained in cases of pneumonia affecting one lobe of a lung, over the unaffected lobe of the same lung, be the latter either the upper or the lower lobe. I forego discussion of the question, wherefore is the sign present in these two pathological connections, simply stating that I suppose in either instance there is an abnormal accumulation of air and increased tension of the alveolar walls within the lobes which yield the sign.

The vesiculo-tympanitic resonance may be illustrated by means of the human lungs, or those of the calf or sheep, removed from the body; inflated artificially within the limit of a normal inspiration, the resonance represents the normal vesicular. Inflated considerably beyond that limit, the emphysematous condition is produced, and the resonance represents that condition.

There is a liability to error in the non-recognition of this sign in certain cases of pulmonary emphysema; and, consequently, to an unfortunate mistake in diagnosis. As a rule, in emphysema, the upper lobes of both lungs are affected, and the lobe of the left in a greater degree than that of the right lung. Now, under these circumstances, the upper lobe in both lungs yields a vesiculo-tympanitic resonance, but this sign is more marked on the left than on the right side, the difference corresponding to the difference in the degree of emphysema. The error is in regarding the lesser degree of resonance on the right, compared with the greater degree of increased resonance on the left

side, as dulness which, taken in connection with the symptoms, would point to a phthisical affection. This error of observation, and consequent mistake in diagnosis, is a not very infrequent occurrence. The relatively lesser degree of resonance on the right side at the summit of the chest, which is supposed to be dulness, is, in fact, a vesiculo-tympanitic resonance, and the intensity is therefore greater than normal. The intensity seems to be diminished because it is relatively less than the still greater intensity on the left side. The error is avoided by attention to the pitch and the quality of the resonance on the two sides. If the disparity in respect of the intensity of resonance be due to a greater amount of emphysema on the left side, the pitch of the sound will be higher on that side than on the right side, and the quality will be distinctly vesiculo-tympanitic. On the other hand, were the disparity due to dulness on the right side, the pitch of sound should be higher on that side than on the left side, and the vesicular quality of the resonance on the left side should be without admixture with a tympanitic quality. A useful practical exercise is to select two patients, one affected moderately with emphysema, and the other with a moderate phthisical affection at the summit of the right lung. In the case of phthisis, the resonance at the summit of the right side of the chest will be less than on the left side, and higher in pitch, the resonance on the left side being vesicular in quality, and lower in pitch. In other words, there is abnormal dulness on the right side. In the case of emphysema, the resonance at the summit of the chest on the right side, as in the other case, will be less intense than on the left side; but the disparity is due, not to a diminished intensity of the resonance on the right side, but to the greater increase of its intensity on the left side; and this increased intensity is accompanied by a vesiculo-tympanitic quality, and a higher pitch than on the right side. That in this case the resonance on the right

side is actually increased; in other words, that on the right, as well as on the left side, the resonance is vesiculo-tympanitic, is shown by a comparison of the resonance over the upper with that over the lower lobe. In cases of emphysema, the standard of health, or an approximation thereto, is obtained by percussion over the lower lobes.

ARTIFICIAL ILLUSTRATIONS OF THE SIGNS OBTAINED BY PERCUSSION.

In conclusion, I hope it will not be deemed too trivial a matter for this occasion, nor an unworthy use of the "staff of life," to show how the signs obtained by percussion may be illustrated by imitating, out of the body, simply and roughly, the morbid physical conditions which these signs represent, using for this purpose, chiefly, the bread-loaf. A resonance analogous to the vesicular, as has been stated, may be produced by percussing a loaf of bread. The first of the four abnormal signs, namely, flatness, is easily enough illustrated. Any substance devoid of air suffices for an illustration. If a part of a loaf of bread be immersed in water for a few moments, the interstices become filled, and we have an imitation of pulmonary œdema; over that portion of the loaf there is flatness. If the absorption of water be not sufficient to fill the interstices, there is dulness. A single loaf may thus be made to illustrate flatness, dulness, and the normal resonance. If, for water, a solution of gelatine be substituted, and a part of a loaf be allowed to remain immersed until the gelatine congeals, we obtain a representation of solidification of lung analagous to that in cases of pneumonia. The three above-named signs may in this way be illustrated.

Dulness may be illustrated and compared with an imitation of the normal resonance, by introducing into one-half of a loaf of bread pieces of some solid mate-

rial. In the present illustration I use sticks of candy. The elevation of the pitch of the dull sound may in this way be shown.

Tympanitic resonance is familiar, of course, from the percussion of the abdomen. The pitch, other things being equal, is higher the smaller the space containing air or gas. Artificially, a bladder, or an India-rubber bag inflated, gives an illustration of a tympanitic resonance. Comparing the resonance of an inflated bag of large size, with the resonance of an inflated lung, the higher pitch of the former may be observed. It is also shown by comparison with resonance from a loaf of bread.

Amphoric and cracked-metal resonance may be illustrated by percussing an India-rubber bulb, such as is used in Davidson's syringe, held down to the ear. It will be seen that the cracked-metal intonation requires a small space with free openings.

Tympanitic resonance within a circumscribed space is shown by removing a portion from the centre of a loaf of bread, leaving only the crust. The resonance over this space may be contrasted with that over the remainder of the loaf. By immersing the loaf for a few moments in water, the tympanitic resonance is brought into contrast with flatness on percussion.

Circumscribed flatness may be shown by filling the space which had given the tympanitic resonance with some solid material. Dough containing no air is a good material for this purpose.

The vesiculo-tympanitic resonance may be artificially illustrated as follows: Take a common loaf of bread. By means of a hollow cylinder remove longitudinal sections in one-half of the loaf. The spaces thus produced yield a tympanitic resonance, and the portions of bread which remain give the vesicular resonance. The vesicular and the tympanitic quality are thus combined with elevation of pitch, the tympanitic quality and the elevation of pitch corresponding to the number of sections removed.

LECTURE II.

AUSCULTATION.[1]

THE exploration of the lungs by means of auscultation divides itself into the study: *First*, of the normal respiratory sounds and their abnormal modifications; *second*, of adventitious sounds, or râles; and, *third*, of vocal sounds, the latter including, with the loud or laryngeal, the whispered voice.

STETHOSCOPES.

The question whether auscultation should be mediate or immediate, is easily disposed of. It should be practised in both ways, according to the circumstances in particular cases. Laennec, as is well known, employed only mediate auscultation. He probably failed to recognize the value of immediate auscultation, because all his observations were made exclusively with the stethoscope. Some of those present may be interested in seeing the kind of stethoscope which Laennec employed. His first instrument was a cylinder of paper, consisting of three quires rolled together and kept in place by paste. He then tried instruments made of metal, glass, and wood, instead of the paper cylinder. Quoting his words, "In consequence of these various experiments, I now employ a cylinder of wood an inch and a half in diameter and a foot long, perforated longitudinally by a bore three lines wide, and hollowed

[1] Delivered December 16, 1882.

out into a funnel shape to the depth of an inch and a half at one of its extremities. It is divided into two portions, partly for the convenience of carriage and partly to permit its being used of half the usual length. The instrument in this form—that is, with the funnel-shaped extremity—is used in exploring the respiration and the râles; when applied to the exploration of the heart and the voice, it is converted into a simple tube with thick sides, by inserting into its excavated extremity a stopper or plug traversed by a small aperture, and accurately adjusted to the excavation. This instrument I have denominated the *stethoscope*."

The stethoscope which I exhibit has an interest aside from the illustration of the kind which Laennec used. It not only belonged to Laennec himself, but was undoubtedly made with his own hands. Its authenticity, as having belonged to Laennec, is indubitable. It was given to me by a former colleague, the late Professor Choppin, of New Orleans, and it was given to him in Paris, by an old physician, who was Laennec's *interne* in the Hospital Necker, and who received it from Laennec himself. Laennec, as is known, was accustomed to make stethoscopes for his own use and for his friends. Moreover, the instrument bears intrinsic evidence of having been made by an amateur mechanic. When in the possession of the *interne* referred to (whose name I have forgotten), it was evidently not regarded with the same respect which it now claims, for the aural end has the traces of a penknife, showing that this sort of petty vandalism is not exclusively an American trait.

In connection with the stethoscope made by Laennec, I exhibit another, which is of interest, as having belonged to Valentine Mott, who obtained it in Paris, when the stethoscope devised by Laennec was in common use. This instrument, as you perceive, was made by a true mechanic. It is nicely polished and the ends are encircled with ivory.

In a recent lecture on the "Evolution of the Stetho-

scope," Samuel Wilks, of London, says, "I know not who invented the instruments with flexible tubes, but I have no doubt that a search into medical history would tell us." The stethoscope, with a single flexible tube, was devised by Carter Nestor Pennock. It was a great improvement on the wooden cylinders of every variety of shape devised by auscultators in different countries. Pennock's stethoscope consisted of a bell-shaped pectoral portion of metal, connected by a hollow flexible tube with a metallic ear-piece, the latter being introduced within the meatus auditorius. A still greater improvement was the binaural stethoscope devised by Cammann, in 1854. The advantages of this stethoscope are so great that, after a fair trial by any one, it is sure to supersede any other at present in use. After nearly thirty years from the date of its introduction by Cammann, it has come into considerable, but not as yet general, use throughout our own country, and it is but little used in other countries. I can speak of this instrument after ample experience, inasmuch as I have used it almost daily since 1855.

In my work on *Physical Exploration*, published in 1856, I stated that it was more difficult to judge of the quality and pitch of sound transmitted by Cammann's stethoscope, than with the wooden cylinder. This was an error, arising from my not then having used that stethoscope sufficiently to appreciate it fully. I corrected the error in a subsequent edition, but the error was quoted by Walshe, and appears in all the subsequent editions of his work on diseases of the lungs. Much to my regret, therefore, I may unwittingly have done something toward retarding the adoption of the instrument by our British brethren. Wilks, however, in his recent lecture, already referred to, appears to consider the binaural instrument as the result of the "evolution of the stethoscope" up to the present time, on the "principle of selection and the survival of the fittest," and he remarks that "the primitive instruments are indeed

only to be found amongst the fossilized curiosities—the relics of former ages—on the antiquated shelves of some very old medical practitioner." The advantages of the binaural stethoscope relate to a conduction of sounds far better than by any uniaural instrument, and to greater facility in its employment. But there are certain obstacles to be overcome in the way of the appreciation of the first of these advantages. Want of knowledge of these obstacles is, I am persuaded, a reason for the fact that, after nearly thirty years, this stethoscope, except in some parts of our own country, is not in common use. In the first place, many stethoscopes, sold as the binaural stethoscope of Cammann, are essentially defective in their construction. Let me indicate the points which are often overlooked by instrument makers. Cammann arranged the curves at the aural extremities so that when the terminating bulb is inserted into the ear, the opening in the bulb should have the direction of the external auditory canal. The conduction of sound is chiefly by the column of air within the instrument. This fact is readily demonstrated by obstructing one of the tubes leading to the pectoral end; the sound is prevented from reaching the ear on the side of the obstructed tube.

Another point in the construction is the size of the terminating bulb. This should not be too large to enter the meatus readily; and, on the other hand, if too small, passing too far into the meatus, it occasions discomfort and even pain. If these points be not properly attended to in the construction, the instrument is almost useless, and many instruments which have come under my notice have been defective therein. The flexible tubes should not be stiff. If they be so, every movement of the pectoral extremity acts within the ear as a lever, and occasions discomfort. The flexible tubes should move noiselessly. Sometimes the tubing used gives rise to a creaking sound which obscures other sounds. The elastic or the spring

which is to hold the ends of the instrument within the ear should be neither too weak nor too strong. All these are minute points, but they are essential. It is proper to state that they are attended to by the instrument makers who made the first stethoscope under the personal direction of Cammann, Messrs. Tiemann & Co., and I have seen stethoscopes made by Ford, of New York, with which no fault could be found. I am afraid it is not safe to trust to the majority of instrument makers, and yet I hesitate to make a sweeping assertion of this kind.

Another obstacle applies to all perfectly constructed stethoscopes, namely, a humming sound belongs to the instrument, and this, for a time, confuses the attention. After a little use this obstacle disappears, the humming ceases to be observed, and the attention is free for the chest sounds. Before this, however, the instrument is often thrown aside as unsatisfactory. I have had much experience in giving practical instruction in auscultation to classes, and I have always found that at the commencement of a course most members of a class appreciate thoracic sounds better with the ear applied directly to the chest than by the use of the binaural stethoscope, but after a short time the stethoscope becomes so attractive that it is difficult to enforce sufficient exercise of the ear in immediate auscultation.

Wilks, in his interesting lecture on stethoscopes, refers to a fact first pointed out to him by Andrew Clark, which relates to a peculiarity of the binaural instrument in the objective appreciation of sounds. It is as follows: "If each ear-piece be separately used, and any sound be made near the mouth-piece, it is heard in the ear itself; but if the two pieces are employed together, the sound is heard at the spot where it is produced." "This fact," he adds, "corroborates the theory as to the value of a double set of senses, ... the two ears listening to the same sound

more thoroughly appreciate its objectivity." This fact is easily verified.

I should, perhaps, refer to Alison's differential stethoscope, which I exhibit. It is a binaural stethoscope, but with a double pectoral extremity. Sounds from two situations are received simultaneously, but from each situation, into one ear. The theory is that the sounds from the two situations can in this way be best compared with each other. The theory is fallacious. If we wish to bring into comparison two sounds which are not musical, or if we wish to compare the quality of two musical notes, we do not desire to listen to both at the same instant, but to each in succession. The increased conduction of sounds by means of a binaural conductor is not obtained by Alison's stethoscope, and a little practice will render it evident that with Cammann's instrument sounds in different situations, listened to consecutively, are much better compared than by the so-called differential stethoscope.

THE NORMAL VESICULAR MURMUR OF RESPIRATION.

Auscultatory sounds, like those obtained by percussion, are to be studied analytically with reference to their differential characters. They are to be studied with special reference to differences in pitch, quality, and intensity; but the other points of distinction which have been mentioned already are to be considered; namely, the duration of respiratory sounds, the rhythmical succession of the sounds of inspiration and expiration, and the apparent nearness to or distance from the ear, especially of vocal sounds. It is needless to say that in the study of auscultation, as of percussion, the analysis of the normal sound should precede and be the point of departure for determining the differential characters of the abnormal sounds which are signs of disease. Entering upon the consideration of respira-

tory sounds, the normal pulmonary murmur of respiration is to be first considered.

Seeking naturally to give an idea of this murmur by likening it to something familiar, Laennec found no better comparison than to the sound of a person breathing tranquilly in sleep. Feeble as is this comparison, a better has not been suggested. The comparison by Skoda to the sound of air sucked in by the lips, is quite as indefinite. It has been compared to the sound of the wind passing through foliage. This is not an improvement on the comparison by Laennec, except that it has something of a poetic savor. From this comparison the quality of the murmur has sometimes been called breezy. Analyzed with reference to its component characters, the intensity varies so much in different healthy persons that nothing distinctive is to be derived from this source. The pitch, as compared with that of the more important of the morbid respiratory sounds, is low. Here is one distinctive feature. The quality, like that of the normal resonance on percussion, is *sui generis*. It cannot be described by words which give any definite idea of it. It has no close analogy to any other sound produced outside of the body. It can only be correctly appreciated by direct observation. The quality may be called vesicular for the same reason that the quality of the normal resonance on percussion is so called; in each of these normal signs the quality is incident to the vesicular structure of the lungs. This structure is so peculiar that it cannot be fully represented by any artificial contrivance by which the movements of air within the structure may be imitated; hence, the fact that the quality of the respiratory murmur, as well as that of the normal resonance on percussion, is *sui generis*. These characters of pitch and quality relate to the inspiratory sound. The relative characters of the expiratory sound are of importance in distinguishing the normal murmur from certain morbid respira-

tory signs. The expiratory sound is much shorter than the inspiratory, and also much weaker. It has no vesicular quality. I know of no better way of expressing the quality than by calling it simply blowing. It is not unlike the sound of the expired breath from the open mouth.

Laennec's explanation of the vesicular respiration was that it is due to the friction of the air in the pulmonary alveoli. I need not take time to show that this explanation is unsatisfactory. To say, as does Skoda, that the murmur is due to the resistance which the cells offer to the air, is simply to state a fact without any explanation. Other explanations, alike unsatisfactory, are, that it is due to contraction of the bronchial muscular fibres in the act of inspiration, as held by Blakiston and Leaning; and, as held by Zamminer and Seitz, that it is produced at the mouths of the infundibula, in the same way as sounds by blowing over the opening of a hollow key. Eichhorst, author of a German treatise on *The Methods of Physical Investigation in Internal Diseases*, (1881), after citing these explanations, assumes that it is a physical impossibility for the respiratory sounds to be produced by the currents of air within the pulmonary air passages, and he considers, therefore, that their source must be within the larynx, being there produced by the projection of the vocal cords, and conducted downward by the air tubes. This is a revival of the doctrine of M. Beau, author of a work on *Auscultation* (1856); an author whose fantastic theories were deemed of sufficient consequence to be always quoted by contemporaneous writers, but almost invariably quoted in order to dissent from them. This glottic theory of the mechanism of the vesicular murmur of respiration is readily disposed of by a very simple experiment. Remove the lungs from the body and separate them from the trachea. Now, if respiration be imitated by means of the bellows, the nozzle being intro-

duced into a primary bronchus, or by means of one of the flexible tubes connected with Davidson's syringe, and the lung be auscultated, either by immediate auscultation or the stethoscope, the vesicular murmur is reproduced, much intensified as compared with the murmur in life. This experiment, assuredly, disproves the physical impossibility of the production of respiratory sounds within the pulmonary air passages, and, consequently, the glottic theory of the production of the vesicular murmur.

For the true explanation (as it seems to me) of the vesicular murmur I am unable to give credit to any writer. In my work on *Physical Exploration*, published in 1856, I submitted the following inquiry: "May not the peculiar quality be owing to the separation of the sides of the cells and the capillary tubes which, to a greater or less extent, come into contact, and, owing to the moisture of the tissues, are slightly adherent during the collapse of the lung incident to expiration?" And I added, "We shall see hereafter that this is the most rational explanation of an important and highly distinctive physical sign of disease." Allusion in the latter sentence was made to the crepitant râle. It is noteworthy that Laennec, in describing the differences between the vesicular murmur and bronchial respiration, says that the latter loses the "slight crepitation" which belongs to the former. The expression "slight crepitation" distinguishes more accurately than any other term the peculiar quality of the vesicular murmur, and, at the same time, it denotes the mechanism. The explanation which, more than a quarter of a century ago, I submitted in the form of an inquiry, I have ever since taught as the true explanation. As corroborative of its truth, I submit the following experiment:

Take the lungs of any animal of sufficient size (a sheep or a calf), twelve or twenty-four hours after the animal has been killed, and introduce the nozzle of a

pair of bellows into either the trachea or one of the primary bronchi. Imitate respiratory acts by means of the bellows. If the stethoscope be placed directly upon the lungs, or with a folded napkin intervening, with each inflation a crepitating character of the sound is apparent. The inflation of portions which contained but little or no air, *i. e.*, collapsed portions, gives a perfect representation of the crepitant râle. Now if the intervening folds of cloth between the stethoscope and the chest be sufficiently increased in thickness, the crepitating character is modified, and the quality becomes hyper-vesicular; in other words, we obtain an intensified representation of the vesicular respiration. The lungs from the human body will, of course, answer as well as those of the calf or sheep. The crepitation may disappear after the inflations by means of the bellows have been continued for some time. The expression by Laennec, "slight crepitation," therefore, expresses not only the character of the murmur, but the mechanism of its production.

I refer to an experiment made by Penzoldt, and cited by Eichhorst, in his work[1] on the methods of physical exploration, as exemplifying either the disadvantage of not having studied respiratory sounds analytically with reference to pitch and quality, or the influence of the imagination on the observation of sounds, or, perhaps, of both these two sources of error. It is stated that if a portion of a solid organ, the liver, for example, be placed over the larynx of a healthy subject, the laryngeal respiration is transmitted to the ear of the auscultator without change; but if a portion of inflated lung be so placed, the laryngeal respiration becomes changed, by its transmission, into a vesicular respiration. This latter statement is adduced by that author to show that the vesicular murmur of respiration

[1] Lehrbuch der Physikalischen Untersuchungsmethoden innerer Krankheiten, von Dr. Hermann Eichhorst, Braunschweig, 1881.

is not produced within the pulmonary alveoli, but that it is the laryngeal respiration conducted through air vesicles. Let any observer, not biased by theoretical expectations, and familiar with the distinctive characters of the vesicular and the laryngeal respiration as determined by analytical study, repeat this simple experiment, and it will be found that there is no essential difference between the sounds as transmitted through the solid organ and the inflated lung. The inspiratory sound does not lose its tubularity, acquiring in its place the vesicular quality; and the relative pitch of the inspiratory as compared with the expiratory sound, is the same as when the stethoscope is placed immediately upon the integument covering the larynx. I make this statement after having repeatedly made the experiment. Whether this statement or that of Penzoldt is correct, can be readily determined by any one who will take the little trouble requisite for repeating the experiment, and comparing the sounds analytically and impartially.

BRONCHIAL RESPIRATION.

Of the morbid respiratory signs, the one which offers, in its distinctive characters, the strongest contrast to those of the normal vesicular murmur, is the *bronchial respiration*, and there is an advantage, therefore, in considering first this sign. Let me enumerate the distinctive characters of the bronchial respiration, as determined by analytical study, although, doubtless, they are familiar to those whom I now address. The intensity of both the inspiratory and the expiratory sound is often greater than that of the vesicular respiration; but this is not an essential feature. The inspiratory sound has no vesicular quality, but, in place thereof, a quality expressed by the term tubular. It is identical with the sound of a current of air through a tube. The pitch is high. The expiratory sound, usually

more intense than the inspiratory, has a tubular instead of the simple blowing quality of the expiratory sound in the normal vesicular respiration; it is higher in pitch than the inspiratory sound; it is prolonged to the length of, or more, of the inspiratory sound, and, instead of being continuous with the latter, as is the case with the inspiratory and the expiratory sound in the normal vesicular respiration, the two sounds are separated by a brief interval of time. The latter character is due to the fact that the inspiratory sound ceases a little before the cessation of the inspiratory act.

No one doubts that the sign having the characters just enumerated is heard over solidified lung. It occurs, therefore, in the second stage of pneumonia, over lung compressed into a solid mass by the pressure of liquid or air within the pleural space; also, in cases of phthisical exudation and induration, as well as in other affections which solidify the pulmonary structure. That the sign represents exclusively solidification of lung, however, is not universally acknowledged. The opinion is held by many that it represents, also, pulmonary cavities. When I come to consider the cavernous respiration, I shall undertake to demonstrate that this opinion is erroneous. I believe the bronchial respiration to be the respiratory sign of complete or considerable solidification of lung, and of no other morbid physical condition. The only room for doubt as regards this limitation of the significance of the sign, is afforded by cases of dilatation of the intrapulmonary bronchi. In these cases, as it seems to me, the presence of this sign is due, not to the bronchial dilatation, but to the condensation of lung surrounding the dilated tubes. The artificial illustration of this sign is easy with Davidson's syringe. If the tube conducting from the central bulb be placed close to the ear, and covered with the hand, in order to exclude extraneous noises, the current of air produced by compression of the bulb causes a well-marked tubular

sound. A similar sound is heard when the tube conducting to the bulb is placed close to the ear, the sound in this instance being caused by an expansion of the bulb. If we attach to the tube conducting from the central bulb other tubes of more or less length, and varying in size, the tubular sound is heard at any point with an equal force of the current of air, and the pitch is found to be somewhat higher the smaller the size of the tube. Blowing into the tube with the mouth will answer as well as Davidson's syringe; and it is not necessary that the current be strong in order to produce a tubular sound. I oppose this simple experiment to the statement by Eichhorst that it is a physical impossibility for the movement of air in the bronchial tubes to produce a sound. It seems surprising that an author should make this statement when it may be disproved by an experiment which can be made at any moment.

The mechanism of the bronchial respiration, of course, involves the passage of air in tubes; but it is a question in what tubes is the sound produced when this sign is heard over the chest. Laennec's explanation was simple, and, in the main, it has not been disproved. He referred the sound chiefly to the passage of a current of air in the larynx, trachea, and the large bronchi at the root of the lungs. He accounted for the absence of the sign over the healthy chest, first, by the presence of the vesicular murmur, which drowns the bronchial sound; and, second, by supposing that the air vesicles containing air conduct sounds less readily than solidified lung. The better conduction of sounds by solidified lung than by the normal inflated lung was denied by Skoda. Skoda based his denial on physical principles and on certain experiments relating to the conduction of the voice. I shall refer to these experiments in connection with vocal signs. I will simply say here that I have repeated them, and with a result the same as stated by Skoda. Another experiment by

Skoda is easily repeated; namely, placing successively over the larynx portions of solidified lung and of inflated lung, equal in volume, and comparing the transmission, through each of these media, of the laryngeal respiration. This experiment shows, according to my observations, that Laennec was in error in supposing that solidified lung is a better conductor of sound than healthy lung. It has been asserted that if a watch be placed alternately beneath portions of solidified and of healthy lung, of equal volume, auscultation shows the solidified lung to be the better conductor of sound. This experiment I have repeatedly made, and with a result the reverse of the assertion that the solidified lung is a better conductor. I may add that up to a recent date I had believed, in accordance with the general belief at the present time, that sounds were better conducted by solidified than by healthy lung containing air.

Laennec supposed that a current of air within the intra-pulmonary bronchi, and even in those of small size, coöperated in producing the bronchial respiration. This supposition has been deemed improbable, at least when an entire lobe is solidified, as in cases of lobar pneumonia. Skoda and others have maintained that a current of air cannot take place within a solidified lobe. This view seems not irrational, considering that the lobe is enlarged to the limit of a full inspiration, that its volume diminishes very little with expiration, and enlarges as little with inspiration, and that the respiratory movements of the chest on the affected side are more or less restricted. Experiment, however, shows that air passes freely through the bronchial tubes within a lobe solidified by pneumonia. In a lung removed from the body, the upper lobe completely solidified and the upper two-thirds of the lower lobe solidified, the unsolidified portion of the lower lobe was readily inflated either by the bellows, or by the breath, the current being inserted either into the

trachea or the primary bronchus. Moreover, in the condition just stated, a vesicular respiratory murmur was appreciable over the lower third of the lower lobe during life, as well as by inflation after death, a fact showing the free passage of a current of air within the intra-pulmonary bronchi of the solidified upper two-thirds of the lobe. I assume, therefore, that it is incorrect to say that air does not pass into the bronchial tubes within a lobe which is completely solidified. Assuming this, the question then is, what part does the air in the intra-pulmonary bronchi have in the production of the bronchial respiration? That Laennec was right in supposing a tubular sound to be produced by a current of air in these tubes is not irrational. Such a sound, in fact, may be produced after death by a current of air from the bellows or the mouth directed into the bronchus connected with a solidified lobe.

But there are grounds for attributing the bronchial respiration, chiefly, if not exclusively, to the larynx and trachea. The fact that in essential characters relating to pitch and quality, the normal laryngeal and the tracheal respiration are identical with those of the bronchial respiration, is perhaps sufficient in itself to prove that the latter is in reality the former conducted into the solidified lung. How can this be, if solidified lung be not a good conductor of sound? The answer to this question is, the conduction is not by the solidified lung, but by air within the intra-pulmonary bronchi. This, as it seems to me, enters into the explanation of the bronchial respiration. The air in the intra-pulmonary bronchi is the conducting medium, as it is in the stethoscope. The explanation does not conflict with the fact that solidified lung is a poorer conductor of sound than healthy lung. For good conduction of sound it is not necessary that the conducting column of air be large. The space containing air within the tubes of the binaural stethoscope, is not larger than that in the medium sized bronchi. The

explanation is consistent with the absence of bronchial respiration when the bronchial tubes are obstructed by either an accumulation of morbid products, or by pressure from without. The following experiment illustrates the conduction by the air within the intra-pulmonary bronchi: In a lung from a body dead with acute pneumonia, the upper lobe was completely solidified. When a current of air from the mouth was directed into the trachea, and the stethoscope applied to the solidified lobe, a well-marked bronchial respiration was appreciable. By compressing with the fingers the bronchus leading to the solidified lobe, a very feeble and distinct respiratory sound only was perceived. A well-marked bronchial respiration returned when the compression was suspended. Dr. Powell, of London, cites an experiment made by MM. Boudet and Chaveau, as demonstrating the conduction from the larynx and trachea of the bronchial respiration. On a horse affected with pneumonia, well-marked bronchial respiration over the solidified lung was ascertained. Tracheotomy was then performed, and when the wound in the trachea was held widely open, the bronchial respiration disappeared, while exaggerated vesicular respiration over the other lung continued. On introducing a tube within the wound the bronchial respiration over the solidified lung returned. This experiment illustrates not only the fact of the conduction from the larynx and the trachea, but also that the conducting medium is the air within the bronchial tubes.

Experimental observations thus appear to prove conclusively that suppression of the vesicular murmur and conduction of the tracheal and laryngeal respiration are the two factors in the mechanism of bronchial respiration, admitting that solidification does not render the lung a better conductor of sound. This admission, however, will be found to be not easily accorded with certain clinical facts. To some of these

reference will be made in connection with vocal signs. One difficulty relates to bronchial respiration. If lung containing air within the alveoli be a better conductor of sound than solidified lung, why is it that we do not have bronchial respiration when the vesicular murmur is suppressed by emphysema? Here is an evident inconsistency. If, however, the explanation which has been given of the bronchial respiration be proven, it is not disproved by apparently conflicting facts. The proper course to pursue is to seek to reconcile these with the explanation. I am not prepared to say how this is to be done in the instance just cited.

The higher pitch of the expiratory, as compared with the inspiratory, sound in the bronchial respiration accords with what is observed when the stethoscope is placed upon the larynx or trachea. The explanation is the narrowed orifice at the glottis by an approximation of the vocal cords in the act of expiration, when compared with the separation of the cords which takes place in the inspiratory act.

CAVERNOUS RESPIRATION.

From the bronchial I pass to the *cavernous respiration*. Laennec recognized the existence of a cavernous respiration, but he regards it as having the same characters as the bronchial respiration, its distinctive feature being a perception as if the air entered a space larger than that of the bronchial tubes. He described two modifications, in one the air seeming to enter and emerge from the ear of the auscultator, and in the other the sound giving the idea of a movable veil between the cavity and the ear. He called the former of these modifications, a blowing respiration, and the latter veiled blowing. It must be admitted that Laennec's account of cavernous respiration is indefinite and unsatisfactory. The criticisms of Skoda are undoubtedly just. But Skoda fell into an error greater

than that of Laennec, with regard to this sign, for he denied *in toto* the existence of a cavernous, as distinct from bronchial respiration. He says (quoting his language), "I consider Laennec's bronchial and cavernous respiration to be one and the same murmur; his blowing bronchial to be a loud bronchial murmur, and his *souffle voilé* to be an unimportant modification of the bronchial respiration." So great has been the influence of Skoda's teachings, that the most recent German writers hold to the identity of the characters of the bronchial and the cavernous respiration. The individuality of cavernous respiration has been, and is acknowledged by English and French authors, but its differential characters were not distinctly indicated prior to 1852. I believe that I do not assume too much in saying that these characters were first fully pointed out in the prize essay published in that year, to which I have already referred, and in my work on *Physical Exploration*, published in 1856. My description of cavernous respiration was based on the analytical study of respiratory sounds with reference to pitch and quality, conjoined with autopsical examinations. In the instances given in my essay, the examinations after death were made, and written reports furnished, by Prof. John C. Dalton.

With reference to its distinctive characters, the cavernous respiration is to be contrasted, on the one hand, with the bronchial respiration, and, on the other hand, with the normal vesicular murmur. Contrasted with the bronchial respiration, the points of difference are not less marked than those which distinguish the bronchial respiration and the normal vesicular murmur. The cavernous inspiratory sound has no tubular quality, and is low in pitch; the expiratory sound is usually more feeble than the inspiratory, its duration or length variable, and its pitch is lower. With an appreciation of these differential characters, the cavernous and the bronchial respiration cannot possibly

be confounded. The quality of the sound in both the cavernous inspiratory and expiratory sound may be called blowing, in distinction from a tubular quality. The quality is like that of the expiratory sound in the normal vesicular murmur. The contrast of the cavernous respiration with the normal vesicular murmur is less strong than with bronchial respiration. In both the cavernous respiration and the normal vesicular murmur, the pitch of the inspiratory and of the expiratory sound is low, and the expiratory is lower in pitch than the inspiratory sound. The essential point of difference relates to quality. The vesicular quality is wanting in the cavernous respiration. Given a respiratory sign in which the inspiration is non-vesicular and non-tubular, with lowness of pitch, the expiration having the same quality but still lower in pitch, the sign can be no other than cavernous respiration. In confirmation of the presence of this sign, clinically, circumstances other than its distinctive characters may be taken into account. It is limited to a circumscribed space; around this space the respiratory sound is either vesicular or the signs of more or less consolidation are present, the latter being true in a large proportion of instances; the coexisting vocal signs and those obtained by percussion are indicative of cavity, and evidence is sometimes obtained by inspection.

Artificially the cavernous respiration may be illustrated by the following simple experiment: The cavity is represented by an India-rubber balloon of the size of a large orange, with thin walls, and two openings connected with a tube of greater or less length. Attaching to one of the tubes a pair of bellows, or, what answers equally well, using the breath from the mouth, the balloon is inflated and the air withdrawn in imitation of the respiratory acts. Placing a binaural stethoscope over the balloon, or listening with it close to the ear, the movement of the air into it and out of it gives rise to a low-pitched blowing sound, the outward lower

in pitch than the inward current. These observations, identical with those of the cavernous respiration, may be contrasted with tubular breathing produced artificially in the manner already stated.[1]

The sign may also be reproduced within a cavity with flaccid walls in a lung removed from the body. I had recently under observation a hospital case in which there was well-marked cavernous respiration at the summit of the chest. After death, in that situation was found a cavity of the size of a large orange, the anterior wall of which consisted of only thickened pleura, and collapsed when the lung was removed from the body. The cavity was readily and largely inflated by the breath directed into the trachea. With the stethoscope applied upon the lung, over the cavity, a loud, low-pitched, blowing sound was perceived when the air entered and when it escaped from the cavity. It is not difficult for those connected with large hospitals to obtain this demonstration of the distinctive characters of the cavernous respiration.

AMPHORIC RESPIRATION.

Amphoric respiration is to be regarded as a variety of the cavernous, and claims but a few words. As is well known, it is a sign *par excellence* of perforation of lung and pneumothorax; but it is not a very infrequent sign of a pulmonary cavity. Whenever present, if pneumothorax be excluded, it is diagnostic proof of a cavity with rigid walls, that is, walls which do not expand notably with inspiration, and collapse with expiration. As produced in cases of pneumothorax, it may be represented artificially by blowing through

[1] The sign is not produced by blowing into a balloon with but one opening. I infer, therefore, that for the cavernous respiration in life, cavities must have openings for the exit as well as the ingress of air.

a small tube into an inflated India-rubber bag of considerable size. As produced in a pulmonary cavity, it is represented by directing a current of air from the mouth or a pair of bellows over the opening into an India-rubber ball of the size of an egg or an orange. It may be demonstrated to be a sign of a cavity with rigid walls in a lung removed from the body. In the specimen just referred to, of a cavity with flaccid walls, which furnished a cavernous respiration after death and during life, a little below this cavity the lung was solidified; but within a circumscribed space well-marked amphoric respiration was perceived when a current of air from the mouth was directed into the lung. An incision revealed a cavity of about the size of an English walnut, surrounded on all sides by solidified lung.

BRONCHO-VESICULAR RESPIRATION.

The three signs which have been considered, namely, the normal vesicular murmur, the bronchial respiration, and the cavernous respiration (the first of these, a normal sign, and the two others abnormal signs), may be said to constitute the simple types of the respiratory sounds heard over the chest. Other signs consist of the characters of these in combination, and may, therefore, be distinguished as compound types. Of these signs, the one which is of most importance I shall consider under the name *broncho-vesicular respiration*. This name was proposed in my work on *Physical Exploration*, published in 1856. It has been adopted, to some extent, by writers in this country. Prof. Da Costa prefers the term *vesiculo-bronchial*. The pressing need of a term expressive of certain morbid auscultatory sounds must, as it seems to me, be evident to any one who has given attention to the study of these sounds. The morbid physical condi-

tions represented by the sounds referred to are the varying degrees of solidification of lung, falling short of a degree sufficient to give rise to a purely bronchial respiration. In a purely bronchial respiration, the inspiratory sound is devoid of any vesicular quality; the quality is entirely tubular. In the broncho-vesicular respiration, the inspiratory sound is both tubular and vesicular; that is, it consists of these two qualities combined. The tubular and the vesicular quality may be combined in different proportions; in some instances the vesicular, and in other instances the tubular, quality predominates. The predominance of the one or of the other of these qualities depends on the degree of solidification; if the solidification be but slight, the vesicular quality exceeds the tubular, and, *per contra*, if the solidification be nearly sufficient for the purely bronchial respiration, there is but little of the vesicular quality, the tubular being in excess. The broncho-vesicular respiration, thus, as a representative sign, covers all the modifications of respiratory sounds, denoting solidification, between the normal vesicular murmur and a purely bronchial respiration. And by means of this sign it is practicable, not only to recognize the existence of solidification which is insufficient in degree to give rise to the bronchial respiration, but to judge of the degree of solidification, that is, whether it be very slight, slight, moderate, or closely approximating to that requisite for a purely bronchial respiration. The combination of the vesicular and the tubular qualities carries with it other characters which correspond to the different proportions in which the two qualities are combined. In proportion as the vesicular quality predominates in the sound of inspiration, the pitch of the sound is low; and, conversely, the pitch is raised in proportion as the tubular quality predominates. The expiratory sound is prolonged, high in pitch, and tubular in quality, in proportion as the inspiratory sound is high in pitch and tubular in

quality; in other words, in proportion to the degree of solidification; and, conversely, the expiratory sound is less prolonged, less high, and less tubular in proportion as the vesicular quality in the inspiratory sound predominates; in other words, in proportion as the degree of solidification is small.

The name broncho-vesicular is intended to supersede such terms as rude, rough, and harsh respiration. These terms are not only inappropriate, but they lead to error. An exaggerated vesicular respiration without solidification of lung may be ruder or more harsh than the sound which represents the latter condition. An imperfectly developed dry bronchial râle may give roughness to the respiratory murmur. These terms, thus, do not denote any fixed, definite, morbid physical condition, and erroneous inferences are liable to be drawn from them in cases of disease. Still more unsatisfactory is the name *indeterminate respiratory murmurs* introduced by Skoda, which embraces the abnormal sounds expressed by the term broncho-vesicular. Under the name indeterminate Skoda includes, quoting his language, "Respiratory murmurs having neither the character of vesicular nor of bronchial respiration." He admits that "No distinct indication can in any particular case be drawn from such a murmur," and he adds, "All respiratory murmurs which give us no information as to the state of the parenchyma of the lungs I call indeterminate respiratory murmurs, and any subdivision of them appears to me to be useless." The name "indeterminate" with the meaning as defined by Skoda, is still in vogue with German writers. The name is applied to sounds due to simple bronchitis, as well as to phthisis and other affections. It must be sufficiently obvious that with the confused idea of the sign, a confusion implied in the name "indeterminate," it cannot be of much practical value in diagnosis. It is far otherwise with the broncho-vesicular respiration, its characters having

been determined by analytical study. The sign is of great practical value in the diagnosis of phthisis, in the early stage of pneumonia, and the stage of resolution, and in other pulmonary affections involving partial solidification of lung. The sign represents the latter condition, and nothing else. It cannot be produced by a simple bronchial affection. It is not less determinate as regards its distinctive characters and its pathological significance, than any of the respiratory signs.

A case of pneumonia during the stage of resolution affords illustrations of all the gradations of this sign. The sign is present as soon as absorption has removed the contents of a sufficient number of air vesicles for a vesicular quality to be perceived in the sound of inspiration. The tubular quality now predominates, and the respiratory sound is still prolonged, high, and tubular. With each successive day, as absorption progresses, the vesicular quality in the inspiratory sound increases, and the tubular quality diminishes. With these changes in the inspiratory sound, the expiratory sound on each successive day is less prolonged, less intense, less light in pitch, and less tubular in quality. At length, resolution being complete, the vesicular quality becomes, for a time, more marked than in health, all the characters of the broncho-vesicular respiration having disappeared.

The characters of the broncho-vesicular respiration may be studied as illustrated in the healthy chest. In the infra-clavicular region, especially the sternal portion, and in the interscapular region, the respiratory murmur, as compared with that over other parts of the chest, is broncho-vesicular; that is, owing to the proximity of the larger bronchi, the characters of the bronchial and of the vesicular respiration are combined. This is more apparent on the right than on the left side. The respiration in these situations has been called the *normal bronchial respiration*. This expression is inexact, inasmuch as the respiratory sounds are not purely

bronchial. It is more correct to say that in these situations there is a *normal broncho-vesicular respiration*. This normal broncho-vesicular respiration may be still better observed by auscultation of the lungs removed from the chest. With the human lungs or those of the calf or sheep, if the nozzle of a pair of bellows be introduced into the trachea, the respiratory acts imitated, and the stethoscope placed either on the lung, or a thin layer of cloth only interposed, the mixture of the characters of the bronchial and the vesicular respiration at and near the apex of the lungs, will be rendered very marked by contrast with the respiratory sounds over other portions.

BRONCHO-CAVERNOUS RESPIRATION.

The combination of the characters of the bronchial with those of the cavernous respiration, and of the cavernous with the vesicular murmur, constitute other compound types. Seitz, the editor of the later editions of Niemeyer's work on the *Practice of Medicine*, has described a respiratory sign which he calls a "*metamorphosizing respiratory sound*." The metamorphosis is in the inspiratory sound. The sound at its beginning is described as rude, and the last two-thirds as bronchial. Bearing in mind that with German writers there is no cavernous, as distinguished from bronchial, respiration, I infer the latter part of the respiratory sound to be cavernous. Such a metamorphosis was described by me in my prize essay, published in 1852, together with the physical conditions found after death. This is one variety of a broncho-cavernous respiration. The first part of the inspiratory sound is a bronchial respiration. It takes place before the air has entered freely into a cavity. One of the characters of the cavernous inspiration is that it is evolved slowly. When the air enters freely into the cavity, the bronchial is superseded by the cavernous respiration. The sign thus

denotes a cavity, with proximate solidification of lung. Another variety is an association of a bronchial expiration with a cavernous inspiration. This variety is not infrequently met with. The explanation is simple. In bronchial respiration, the expiratory sound, as a rule, is more intense than the inspiratory. The inspiratory sound may be relatively quite feeble, and it is sometimes wanting. On the other hand, the expiratory sound in cavernous respiration, as a rule, is feeble, and may be quite so, or it may be wanting. Now, it is easy to understand that when a cavity is situated near a portion of solidified lung, the auscultator may obtain over the cavity an inspiratory sound which is cavernous, that is, low in pitch and blowing in quality, associated with an expiratory sound which is bronchial, that is, high in pitch and tubular in quality.

VESICULO-CAVERNOUS RESPIRATION.

The characters of the vesicular and of the bronchial respiration are combined when the pulmonary structure surrounding a cavity remains intact, or but little affected. The vesicular quality is then derived from the surrounding lung. The recognition of this compound type may seem a refinement in auscultation, but that in certain cases it is readily recognized, clinically, I am well satisfied. It may be called a *vesiculo-cavernous respiration*.

DIMINISHED AND SUPPRESSED VESICULAR MURMUR, AND INTERRUPTED RESPIRATION.

Diminished vesicular murmur, without change in pitch and quality, and suppression of the murmur, which are physical signs of much value, taken in connection with other signs and with symptoms, do not here claim consideration. Of the sign called inter-

rupted, wavy, and cog-wheeled respiration, I will only remark that, as an isolated sign, it has but little clinical importance; it derives whatever value belongs to it from its association with other signs. I shall conclude this discourse with some remarks on prolonged expiratory sound, either existing without an inspiratory sound, or when the latter is too weak in its character to be distinctly appreciable.

PROLONGED EXPIRATION.

It is remarkable that Laennec should have given so little attention to the study of the sound of expiration. James Jackson, the younger, was the first to appreciate the clinical value of a prolonged expiratory sound. As early as 1832 he called attention to the significance of a prolonged expiratory sound at the summit of the chest in the diagnosis of pulmonary phthisis. He noticed not only the prolongation, but its resemblance in character to the prolonged expiration in bronchial respiration. Since his observations this sign has been included in the group of signs to be sought after in the diagnosis of phthisis. It may or may not have significance in relation to that disease. A prolonged expiration which may be more or less high in pitch and tubular in quality, is not very infrequently observed in healthy subjects at the summit of the chest on the right side. It belongs to the normal broncho-vesicular respiration, and may be present when the characters of this sign, owing to feebleness of the inspiratory sound, are not appreciable. I have known a prolonged high-pitched expiration to exist on both sides at the summit of the chest, no other morbid signs being therewith associated. Absence of other signs of disease is the fact to be relied upon in judging that the prolonged expiration is a normal peculiarity. But, as a morbid sign, prolongation of the expiratory sound is not always evidence of phthisis nor of any affection involving

solidification of lung. It is a sign in cases of pulmonary emphysema, and may occur whenever the expiratory act is increased in force and length, or whenever there is an obstacle to the free exit of air from the smaller to the larger bronchial tubes. How is this difference in the significance of the sign to be recognized clinically? This question can be definitely answered. If the prolonged expiratory sound be high in pitch and tubular in quality, exclusive of the instances in which it has these characters as a normal peculiarity at the summit of the chest on the right side, the sign denotes lung solidified by a phthisical or some other solidifying morbid process. It has precisely the same significance as when it is associated with a high-pitched tubular inspiratory sound in the bronchial respiration. If, on the other hand, the prolonged expiratory sound have characters, as regards pitch and quality, the same as in the normal vesicular murmur, differing only in length and intensity, it is not a sign of phthisis, nor of any other affection involving solidification of lung. This variety of prolonged expiratory sound, associated with other signs, is diagnostic of pulmonary emphysema.

These differential characters pertaining to the sign, the difference in its significance being correspondingly marked, exemplify the importance of the analytical study of auscultatory phenomena. With few exceptions in works treating of auscultation at the present time, a prolonged expiratory sound, as a morbid sign, is considered without reference to the differences in pitch and quality on which depend its diagnostic significance. If these differences be not taken into account, the sign is as likely to lead to error as to a correct diagnosis.

LECTURE III.

AUSCULTATION.[1]—Concluded.

The adventitious sounds or râles produced by acts of respiration, and the vocal signs, will furnish the topics to be considered in this lecture.

MOIST AND DRY BRONCHIAL RALES.

The bronchial râles, moist and dry, were studied and explained by Laennec so completely and accurately that they need at the present time, in these regards, no modifications nor additions. Diversified as are the sounds, he reduced them to three signs, namely, the mucous (more correctly called the moist bronchial or bubbling râles), the sonorous, and the sibilant râles. These are distinct from the crepitant, the subcrepitant, and the crackling râles, which require separate notice. The crepitant and the crackling râles are distinguished as not bronchial but intra-vesicular in their source. It is interesting to contrast this simple division by Laennec with the over refinement by Fournet. That author describes five varieties of intra-vesicular râles, five varieties of extra-vesicular râles, and four varieties of bronchial râles. Skoda aimed at simplicity in his division, but it is in striking contrast to the simple arrangement by Laennec. Skoda divided the râles which have been referred to, into: 1st. A vesicular râle; 2d. A consonating râle; 3d. A dry crepitating râle; and,

[1] Delivered January 13, 1883.

4th. Indeterminate râles. The effect of this division and nomenclature is to substitute confusion and error for clearness and correctness. It is needless to mention here the physical conditions which the moist and dry bronchial râles represent. I will make one practical remark respecting the clinical significance of the moist or bubbling (or, as called by Laennec, the mucous) râles—namely, they are often wanting in bronchitis affecting the larger and medum-sized tubes, for the reason that adhesive mucus and solid sputa are not suited for bubbling. These râles occur when the bronchial tubes contain pus, serum, blood, or liquefied tuberculous deposit.

It is pleasant to find in Skoda's treatise a statement, with respect to these râles, of an important practical fact. I quote the statement referred to as follows: "The pitch of a râle generally corresponds to that of the respiratory murmur which is either replaced by or accompanies it." Again, "The acute, large, or unequal bubbling thoracic râles indicate the same condition of the lung tissue as bronchophony and bronchial respiration." The importance of this fact is perhaps not always appreciated by auscultators. It enables the auscultator to determine by the râles alone, if respiratory sounds be, as they sometimes are, absent, whether solidification of lung exists or not. For examples, the bubbling râles in capillary bronchitis and pulmonary œdema are always low in pitch, denoting non-solidification of lung. These râles are high in pitch in a lobe solidified by pneumonia or by a phthisical affection. It does not seem to me easy to explain this effect upon the pitch of râles by solidification of lung, but it is not less true, on that account, as a clinical fact determined by observation.

The moist bronchial râles are easily illustrated artificially as follows: Attach to a Davidson's syringe a long India-rubber tube, or a series of tubes differing in size. After passing a little water through the tube

or tubes, bubbling sounds are produced by a current of air for several hours. To observe these the tube should be held close to the ear, and other sounds excluded by covering the ear and the tube with the palm of the hand. This experiment shows that a very little liquid is sufficient to produce much bubbling, and therefore the abundance of moist bronchial râles is not evidence of much liquid.

The dry râles, sibilant and sonorous, can be illustrated with India-rubber tubes, either attached to Davidson's syringe or using the breath, by contracting the tubes at certain points. This may be done by either applying ligatures or compression with a forceps. It requires, however, some pains to secure the precise amount of contraction of the tubes necessary for the production of whistling and snoring sounds. The experiment, thus, while it demonstrates the mechanism of these râles, is defective in some accessory physical conditions which are involved in their production in cases of asthma and bronchitis.

SUBCREPITANT AND CREPITANT RALES.

Laennec described a moist crepitant râle, a subcrepitant râle, and a dry crepitant or crackling râle. His descriptions, as far as they go, are exact, but he failed to draw a sharp line of distinction between the râles now well known as the crepitant and the subcrepitant. The error of attributing the crepitant as well as the subcrepitant râle to the bubbling of liquid, probably occasioned perplexity. The fact that the crepitant râle is heard with inspiration and never with expiration, would not occur to him as probable if both were bubbling sounds; hence he failed to recognize this important distinctive point. That he confounded the crepitant and the subcrepitant râle, seems certain; yet he regarded the crepitant râle as the pathognomonic sign of pneumonia. In this respect he was in

advance of his commentator, Skoda, who declared that the crepitant râle is only occasionally limited to inspiration, and that "no distinctive line can be drawn between crepitating, subcrepitating, and mucous râles." This must seem a remarkable statement to the auscultators of to-day; at all events, to those of this country. Not less remarkable is Skoda's statement that he has not often observed, in cases of pneumonia the crepitant râle as described by Laennec.

The true explanation of the mechanism of the crepitant râle was first given by an American writer, the late Dr. E. A. Carr, of Canandaigua, New York, in a communication published in the *American Journal of the Medical Sciences*, in 1842. This explanation attributes it to the separation of the walls of air vesicles in the act of inspiration, more or less of the walls having become *adherent* at the end of the act of expiration, from the presence of adherent mucus. It is probably more accurate to say that the sides of the ultimate bronchial tubes or bronchioles adhere at the end of inspiration, and are separated by the act of inspiration; hence, it is not strictly correct to call the crepitant râle a vesicular râle. It is not a bubbling sound, and the application to it of the term moist, is one of the few instances in which Laennec's observations were influenced by his reasoning. A true crepitant râle is characterized by dryness; but it is to be considered that Laennec did not discriminate sharply the crepitant from the subcrepitant, the latter being a moist or bubbling sound. After the lapse of forty years the explanation by Carr has made considerable headway as regards its general adoption. The explanation is so simple, it accounts for the peculiar characters of the sign so completely, and its correctness may be rendered so demonstrative by artificial illustrations, that it would seem as if it should at once have been adopted. Carr's imitation of the râle was by moistening the thumb and forefinger with a little mucilage, and alternately

pressing them together and separating them, held close to the ear. As already stated, a crepitant râle may be obtained by auscultating directly a healthy lung after its removal from the body. The illustration is better after twenty-four hours than shortly after the lungs are removed. But the most perfect illustration was by means of an article made ten or twelve years ago, of India-rubber, to serve as a substitute for a sponge. This article was in structure like a very fine sponge; when compressed and then allowed to expand, holding it close to the ear, the representation of the crepitant râle was as perfect as possible. This illustration furnished demonstrative proof that the râle is not a bubbling sound, and that it is produced by the separation of adherent surfaces, for in using the article to illustrate the sign, not the least moisture was required.[1]

The subcrepitant râle may be illustrated with the lungs of the calf or the sheep. After having obtained, by application to the lungs of the binaural stethoscope, the crepitant râle, which, as has been seen, may be in this way illustrated, a certain quantity of liquid (water or glycerine) is to be poured into the trachea. Now, imitating respiration by inflating with the bellows, the subcrepitant râle is beautifully represented. The bubbling is extremely fine, and is associated with crepitation. It is heard with the current of air which represents expiration as well as that representing inspiration. A similar association of the crepitant with the subcrepitant râle is by no means uncommon in pneumonia, and is, perhaps, the rule in the resolving stage of that disease. It is probable that this fact contributed to Laennec's confusion as regards these two râles.

[1] A similar article is now made and used by artists. Something, however, is combined with the India-rubber, making it better adapted for its use as a sponge, but impairing very much its fitness to illustrate the mechanism of the crepitant râle.

A recent theory attributes the crepitant, the subcrepitant and, indeed, other bubbling râles, to intra-pleural exudation and adhesions. The experiment just stated demonstrates the fact that each of these râles may be produced within the lungs removed from the body. Autopsical examinations in cases in which these râles have been observed during life, show the existence of physical conditions analogous to those in that experiment. The râles are found in cases in which examinations after death show no pleural exudation or adhesions. On these data may be based the assertion that the intra-pleural theory of the production of these râles is, to say the least, purely gratuitous. This is not saying that the stretching of fibrin, or of newly formed tissue between the pleural surfaces, may not sometimes produce sounds which simulate these râles. I cannot, however, think that the ear of an experienced auscultator can be thereby often deceived.

The pleural friction sounds with which every practical auscultator is familiar, have characters which are sufficiently distinctive. They are expressed by such terms as grazing, rubbing, creaking, grating, rasping, and not by bubbling or crackling. They are irregular in their connection with the respiratory acts, occurring with some and not with other successive acts; now heard in inspiration and now in expiration; sometimes at the beginning and at other times near the end of either inspiration or expiration; in some instances being continuous, in other instances interrupted or jerking, and not infrequently disappearing temporarily after repeated forced respirations. These are not characters in common with the crepitant or the subcrepitant râle. A highly distinctive feature is their apparent superficial seat. They seem to be produced directly beneath the ear applied to the chest, or the stethoscope. Râles produced within the air tubes or vesicles differ in this regard. Of the clinical significance and impor-

tance of pleural friction sounds, it is unnecessary to speak.

Laennec described a râle under the name "dry crepitant, with large bubbles or crackling" (*râle crepitant sec à grosses bulles ou craquement*). He stated, as a distinctive feature, that it is limited to the inspiratory act. He supposed it to be a diagnostic sign of pulmonary emphysema. There is an obvious incongruity in calling the sign a dry râle, with large bubbles. The term crackling is more definite. At the present day this râle is not generally recognized as a distinct sign. Skoda admitted its existence, but remarked, somewhat flippantly, that they who had failed to recognize it had not lost much. A râle such as Laennec described is the crackling at the summit of the chest, which is one of the accessory signs in the early stage of phthisis. It is sometimes heard at the summit of the chest on both sides in healthy persons at the end of a very deep inspiration. It is certainly not of much diagnostic value in pulmonary emphysema, but I have sometimes met with it occurring in connection with that affection. It has seemed to me to originate in the portions of lung not having become emphysematous. I have regarded it as an abnormal exaggeration of the vesicular quality of the inspiration in the normal respiratory murmur.

Metallic tinkling, a sign with characters so distinctive that it is recognized at once from a description of them, has given rise to diversity of opinion and much discussion in regard to its mechanism, there being no lack of agreement in respect of its clinical significance. Jacob Bigelow, in 1839, demonstrated by a few well-devised experiments that the dropping of liquid in a space containing liquid and air gives rise to the sign. This was Laennec's explanation. Bigelow, however, demonstrated that the sign was also produced by the explosion of bubbles on the surface of a liquid, within a cavity containing both liquid and air. This was the explanation given by Bean, Dance, and Spittal.

These two explanations require the presence of liquid as well as air within either the pleural cavity or a pulmonary excavation. A third mode of production is the bursting of bubbles of air at the mouth of a fistulous opening into the pleural cavity, or at the point of communication of a bronchial tube with a pulmonary excavation. It is easy to demonstrate the correctness of each of these explanations. The sign may be produced by either of the three modes, and, clinically, each is applicable to certain instances. For this demonstration we may employ the India-rubber bag belonging to the modern foot-ball, which has been found serviceable in illustrating tympanitic resonance on percussion, and amphoric respiration. If the opening into this bag be connected with an India-rubber tube of sufficient length, the bag partially filled with a liquid and inflated, metallic tinkling may be produced by holding the bag so that the opening is dependent, and causing bubbles at the surface of the liquid by introducing air through the tube from the mouth. It will be found that the quantity of liquid within the bag must not be large, otherwise gurgling is produced instead of the tinkling sounds. Tinkling sounds may be produced by making the other end of the bag dependent, and thus causing drops to fall from above to the surface of the liquid. Shaking the bag will also produce the sounds. Now, if the liquid within the bag be allowed to escape, and a few drops remain in the tube, on blowing into the latter and holding the bag close to the ear, excellent examples of this sign are obtained. This last experiment gives the best illustration, and it is probable that it exemplifies the most frequent of the modes in which the sign is produced clinically.

We are now to consider vocal signs, and, first, the signs which are incident to the laryngeal or loud voice.

The names bronchophony, pectoriloquy, and ægophony, applied by Laennec to vocal signs, are still, and

will probably always remain, in common use. It is, however, conceded on every side that in the description and interpretation of the first two of these signs (bronchophony and pectoriloquy) Laennec's treatise is defective. It is evident, in reading that portion of his treatise which is devoted to these signs, that his mind was biased by the desire to establish pectoriloquy as a cavernous sign. According to his description of bronchophony, "the voice seldom traverses the stethoscope." In pectoriloquy, on the other hand, the voice traverses the stethoscope either wholly or in part. By this language he means, doubtless, that the voice in pectoriloquy seems to be more or less near the ear of the auscultator. The distinction is a just and good one, but, as will presently be seen, it is not characteristic of a cavernous sign. The confused idea in Laennec's own mind is shown by his division of pectoriloquy into three varieties, namely, perfect, imperfect, and doubtful. The last variety, as he admits, is not to be distinguished by its intrinsic characters from bronchophony. A doubtful physical sign can hardly have much clinical value, and, quoting from an essay by Oliver Wendell Holmes, "To speak of the tones of the voice being heard a *short distance up the stethoscope*, is to present to the student a distinction of such tenuity as must seem beyond the reach of his faculties."[1] The vulnerability of this part of Laennec's treatise did not, of course, escape the critical eye of Skoda; but, if it be correct to say there is confusion in the account of bronchophony and pectoriloquy by Laennec, there is "confusion worse confounded" in Skoda's description. Skoda, after distinguishing the normal variations of the thoracic voice by the terms, *loud*, *clear*, and *humming* (terms which are not very sharply distinctive), and after concluding that bronchophony

[1] *Vide* Prize Dissertation. Published by order of the Massachusetts Medical Society, Boston, 1836.

and pectoriloquy are identical, makes the following abnormal varieties: "1. The voice, accompanied by a concussion in the ear, completely traverses the stethoscope—loud bronchophony, which may be either clear or dull. 2. The voice, unaccompanied by concussion in the ear, passes incompletely through the stethoscope —weak bronchophony. 3. An indistinct humming, with or without a barely appreciable concussion in the ear."

It will be observed that there is no provision for ascertaining these modifications by immediate auscultation—the stethoscope is essential. I can sympathize with the student or the practitioner who attempts to grasp the distinctions set forth in this quotation, and to apply them at the bedside. The perplexity is not diminished by reading all that the author has to say with a view to their elucidation in the pages which follow. Adopting Skoda's account of vocal signs, it is not to be wondered at that a late German author, to whom I have repeatedly referred— Eichhorst—thus introduces a chapter on auscultation of the voice: "Its diagnostic value has been much over-estimated. It hardly ever furnishes original diagnostic results, and, almost without an exception, its object is to confirm conclusions obtained by previous methods of investigation." I am sure that this quotation does not express the estimate in which the vocal signs are held in our country, as bearing on the diagnosis of pulmonary diseases.

How are we to determine the signs which are incident to the loud voice and their differential characters? There is but one way, and that is by means of the analytical method of study. This method requires, as the point of departure for determining the morbid signs, study of the thoracic voice in health. This study shows that if we except characters which in some healthy persons belong to the voice as transmitted over the extra-pulmonary bronchi, especially on the right side

of the chest, the *normal vocal resonance* is low in pitch, the voice seems diffused and distant from the ear, and it is accompanied by a perception of more or less vibration, thrill, or fremitus, which is not an acoustic but a tactile sensation. It is important to discriminate the fremitus from the resonance.

BRONCHOPHONY.

Proceeding now to morbid signs as determined by analytical study, it is a highly distinctive abnormal deviation from the lowness in pitch, the distance and the diffusion of the normal vocal resonance, when the thoracic voice is raised in pitch, seemingly concentrated and near the ear. These characters are present when the voice is transmitted through solidified lung. Calling the sign distinguished by these characters bronchophony, it always denotes a certain degree of solidification of lung, if we except the so-called normal bronchophony sometimes found on the right side of the chest, and in rare instances on the left side, at the summit, over the extra-pulmonary bronchi in healthy persons. The abnormal sign is rarely wanting if the requisite degree of solidification of lung exist. It is not necessary, for the production of this sign, that the solidification be complete. It is obtained in pneumonia and other affections which involve solidification of lung, when the associated respiratory sign is not the bronchial, but the broncho-vesicular respiration, and, of course, the normal bronchophony is heard over lung not solidified, its production being evidently due to the proximity of the large bronchial tubes. Observe that intensity of sound is not included among the distinctive characters of bronchophony. The voice may be either loud or weak. If the voice be concentrated, near the ear, and high in pitch, no matter how feeble the sound, it is not less bronchophony than if the sound were ever so loud, and the diagnostic significance is the same.

INCREASED VOCAL RESONANCE.

The vocal resonance may be abnormally loud, with no marked alteration either in concentration, nearness to the ear, or pitch. A simple increase of the resonance, therefore, it remaining low, distant, and diffused, is a vocal sign distinct from bronchophony, and which, as clinical observations in connection with examinations after death show, represents solidification of lung. The solidification thus represented is not sufficient in degree to give rise to bronchophony. Increased vocal resonance, as distinct from bronchophony, is also a cavernous sign. This statement is based exclusively on my own observations. If a cavity of considerable size be situated near the superficies of the lung, and not surrounded by solidified pulmonary structure, the vocal resonance is notably increased, and may be extremely intense, without the characters which are distinctive of bronchophony. The sign is often associated with cavernous respiration, and but rarely with amphoric respiration, the latter sign requiring solidified lung around the tuberculous cavity.

PECTORILOQUY.

Pectoriloquy, from its derivation, signifies thoracic *speech* as distinguished from thoracic *voice*, bronchophony having the latter signification. Strange to say, Laennec, who introduced these terms, did not employ them in accordance with this etymological distinction. His description of pectoriloquy embraced only the transmission of the voice. The confusion which has always existed, and still exists, in the use of the terms pectoriloquy and bronchophony, is readily and completely done away with by the use of these terms in the true etymological sense of each. Bronchophony should be considered as meaning transmission of the

voice, together with the characters which are distinctive of that sign. Pectoriloquy should be limited to the transmission of speech, that is, of articulated words, through the chest.

With this definition, Is pectoriloquy to be rejected as a superfluous sign, as is done by Skoda? By no means. There is no sign better individualized than this. It is easy to decide, in any instance, whether or not the speech, that is, articulated words, is perceived. There is one liability to error, namely, the auscultator may hear the words from the mouth of the patient, and fancy that he hears them through the chest. In order to avoid this error, if immediate auscultation be employed or an uniaural stethoscope, the ear which is not to receive the chest sounds should be effectually closed. This, by the way, is a precaution to be observed in listening to any of the vocal signs. To make assurance doubly sure as to the existence of pectoriloquy, the auscultator should not know beforehand the words which the patient speaks. I have been accustomed to use this precaution in giving practical lessons in auscultation, and I have been led to notice that some persons seize much better than others, words transmitted through the chest.

Is pectoriloquy a cavernous sign? It is, and it is not. Articulated words may be transmitted through a pulmonary cavity. It is then purely a cavernous sign. They may be transmitted through solidified lung; it is then, of course, a sign not of a cavity, but of solidified lung. Now, is it practicable to determine clinically, whether the sign denotes a cavity or not? I answer in the affirmative. The discrimination is easy. If the thoracic voice which accompanies the pectoriloquy have the characters which are distinctive of bronchophony, the transmission of speech is through solidified lung. The two signs, pectoriloquy and bronchophony, are conjointly present. If, on the other hand, the bronchophonic characters are wanting, and the pectoriloquy

is accompanied by merely an increased intensity of the transmitted voice, the transmission of speech is through a pulmonary cavity. The two signs, pectoriloquy and increased vocal resonance, are then conjoined. There is, therefore, a cavernous pectoriloquy, and there is a bronchophonic pectoriloquy, the differential characters being well marked and easy of recognition.

ÆGOPHONY.

Ægophony claims but a few remarks, not meaning to imply that it is a doubtful sign, as regards either its distinctive characters or its significance, but because, owing to correlative signs, it might easily be dispensed with in diagnosis. In fact, now when the exploratory puncture of the chest is employed in diagnosis without reserve, the auscultatory signs of pleuritic effusion are of much less practical importance than heretofore. Recently cases have been reported and papers published to show that, by means of the transmission of the whispered voice, it may be determined whether liquid within the pleural space be purulent or serous; but why waste time in observations and discussions relative to this point of inquiry, when by means of a hypodermic syringe in less than a minute the character of the liquid can be ascertained demonstratively?

It is a curious fact that in Laennec's treatise more than one-sixth of the portion of the work occupied with the consideration of the physical signs obtained by auscultation, is devoted to ægophony. In the greater part of this space, however, he discusses the mechanism of the sign. No one has found fault with or improved upon his description of the sign, and the name is well applied to it in certain instances, although the cry of the goat is less familiar to the people of this country than to the citizens of Paris. I believe that Laennec's interpretation of the sign is the true one, without regard to his views of the mechanism. The sign denotes

a certain amount of pleuritic effusion. From Skoda's statement that he has heard ægophony in cases of simple pneumonia, I infer that either the pneumonia was accompanied by the requisite amount of liquid within the pleural space, or that he confounded ægophony with bronchophony. Analytically studied, ægophony has the same characters as bronchophony, minus the nearness to the ear, added to which is the tremulous or bleating quality. The sound is more or less distant from the ear, and is rarely accompanied by fremitus. I believe the sound to be essentially a bronchophonic voice, rendered more or less distant, the fremitus suppressed, the other modifications being due to its transmission through a stratum of liquid. Hence, the physical conditions for its production, in a case of pleurisy, are, the presence of a certain quantity of serous or purulent effusion, and condensation of a portion of the compressed lung sufficient to give rise to bronchophony. The latter condition is likely to exist with a moderate amount of effused liquid when the upper third of the lung is adherent to the chest wall by either recently exuded lymph or old adhesions, and the compressing force of the liquid as a consequence is brought to bear on the lower two-thirds of the lung.

I have repeatedly endeavored to connect bronchophony with ægophony by placing between the chest and the stethoscope an India-rubber bag containing varying quantities of liquid, in a situation where the bronchophonic voice was marked, in cases of pneumonia. The pitch, of course, is that of ægophony, and the voice is distant, but the tremulous, nasal, or bleating characters of the sign are wanting. The modifications expressed by these terms, therefore, depend on conditions not embraced in this experiment. Laennec attributed these modifications to flattening of the larger bronchi by the pressure of liquid, together with movements of the latter caused by the vibration of the lung. If this explanation be not satisfactory, it is cer-

tain that none better has been proposed. A bag of liquid interposed between the larynx and the stethoscope, occasions none of the characters of ægophony, and for a good reason, to wit, laryngophony is not bronchophony. The vocal sound from the larynx is characterized by intensity, concussion, and fremitus, without that elevation of pitch which is essential in order to render it bronchophonic.

Reverting to bronchophony and to increased vocal resonance, while the clinical significance of these important signs admits of no doubt, the mechanism of their production is open for discussion. Laennec considered that an essential element in the mechanism is a better conduction of sound by solidified than by healthy lung. Skoda's experiments prove the reverse of this. If the lungs be removed from the chest, after death from pneumonia, a lobe or more being completely solidified, and an assistant speak through a tube, the end of which is applied first to a solidified and afterward to a healthy lobe, it will be found on auscultation with the binaural stethoscope that the voice is conducted further by the healthy than by the solidified lung.[1] Other experiments referred to in my last lecture also show that lung containing more or less air within the alveoli conducts sound better than either solidified lung or portions of the liver. The same result obtains if the voice of the assistant be directed into the larynx or trachea, and the experimenter auscultate in alternation a healthy and solidified lung. Laennec's explanation of the mechanism is, therefore, not tenable. To meet the difficulty, Skoda resorted to the theory of consonance. The adequateness of this explanation has been sufficiently disproved, and I need not take any time for the discussion of it. Here, then, is an apparent incongruity between an acoustic fact

[1] Holden's resonator makes an excellent speaking tube in these experiments.

and clinical experience. We must admit that healthy lung conducts sound better than solidified lung. *Per contra*, it cannot be doubted that the thoracic voice, in cases of disease, is often louder over solidified than over healthy lung. Observations during life conjoined with examinations after death prove this incontestably. Which, then, is to give way, the acoustic fact or clinical experience? I answer, neither the one nor the other is to give way. The incongruity is, if possible, to be removed. The acoustic fact is not, for an instant, to be considered as invalidating the significance of the signs. Their significance rests on clinical and autopsical data which are not to be put aside in consequence of any apparent antagonism by physical facts. It is certain that such an antagonism must be only apparent, not real, and the object of inquiry should be to reconcile the apparently antagonistic facts with the truths of clinical experience.

It is to be considered that we cannot artificially combine all the physical conditions involved in the thoracic voice of either disease or health, nor even by means of the lungs removed from the body. The difficulties connected with artificial respiration are such that this method of experimentation is entirely out of the question; but something can be done toward a reproduction of the vocal signs by transmitting the voice through the larynx or trachea into the lungs after death. The contrast in the degree of conduction when the voice is transmitted through the trachea or a primary bronchus into a solidified lobe, with the transmission when the end of the speaking tube is placed upon the surface of the same lobe, proves that in the former instance the sound is conducted, not exclusively by the lung substance, but by air within the pulmonary bronchi. The agency of air within the bronchi is also demonstrated by the following simple experiment: Insert the end of the speaking tube into the trachea, the lungs remaining attached, removed from the body and artificially

inflated. The lungs of the calf or sheep will answer as well as those from the human subject. An assistant speaks into the tube, and the vocal resonance over the lung is obtained by means of the binaural stethoscope. Now, introduce a plug of cotton-wadding into the trachea, and compare the vocal resonance with that produced when the trachea is not thus obstructed. The intensity of the resonance is diminished, at least one-half, by plugging the trachea. The question, therefore, as to solidified or healthy lung being a better conductor of sound, has really not very much to do with the explanation of the well-established clinical truth that when the lung is solidified, often but not invariably, the thoracic voice is abnormally intensified. The explanation of this fact has more to do with the air contained within the bronchial tubes than with the solidification of lung. It is easy to account for the transmission of voice sounds from the larynx or trachea, as well as of the laryngeal and tracheal respiratory sounds, if we assume that a column of air extends into the bronchi within the lungs. We have only to instance the stethoscope and the speaking tubes in our houses, for familiar illustrations of the conduction of the voice by the medium of air contained in tubes.

The distinctive characters of bronchophony can be reproduced after death over solidified lung by speaking into the trachea. The voice, transmitted through a solidified lobe, the binaural stethoscope being applied to the lobe, is raised in pitch and near the ear, whereas it is diffused and comparatively distant when transmitted through a healthy lobe. An effect of solidification is thus to modify the vocal resonance as in life. I do not attempt to give an explanation of the manner in which these modifications are produced. The intensity of the thoracic voice, transmitted after death through a solidified lobe, is not increased; but increased intensity, as has been seen, is not to be considered an essential element of bronchophony. The

bronchophonic voice may, or may not, be louder than the normal vocal resonance. But we have to inquire, why is it that bronchophony is ever more intense than the normal thoracic voice, and how is to be explained an abnormal increase of vocal resonance without the bronchophonic modifications whenever this is a sign of partial solidification of lung? The *rationale* must have to do with the air contained within the bronchial tubes. I submit the following explanation: Suppose a case of pneumonia in the second stage, one lobe, at least, being completely solidified. The solidified lobe is enlarged in volume nearly or quite to the limit of the expansion at the end of the inspiratory act. Its volume does not diminish with expiration, but remains the same in the inspiratory and the expiratory act. The respiratory movements on the affected side are more or less restricted. Now, the voice is produced by the breath in the act of expiration, that is, it is produced when the current of air is passing from the bronchial tubes of the healthy lung, in consequence of the diminution of the volume of this lung by the contraction of the thoracic space. It seems fair to assume that, under these circumstances, the bronchial tubes on the affected side contain more air than on the healthy side, and that there is less of a current of air in the expiratory act toward the trachea and larynx. Do not these points of difference account for a better conduction of the voice by air within the bronchial tubes on the affected side?

The following experiment has some bearing on this question: A hospital patient under my observation, died with acute pneumonia, the physical signs during life showing solidification of the entire left lung. In order to compare the transmission of the voice before and after the removal of the contents of the chest, the larynx was exposed and within it the end of the speaking tube inserted, the chest walls remaining intact. Blowing into the tube with the bellows and with the

mouth produced over the upper solidified lobe a high-pitched tubular sound, and over the right upper lobe a vesicular murmur. Moist bronchial râles were heard on both sides, but their presence did not drown the tubular and the vesicular sounds. Speaking through the tube and auscultating with the binaural stethoscope, well-marked bronchophony was heard at the upper part of the chest on the left side, over the solidified lung, and on the healthy side, in the same situation, a resonance corresponding to the normal. The bronchophony, although well marked, was much less intense than during life. Exposing now the lungs, by removing the sternum, and applying the stethoscope upon the upper solidified lobe, bronchophony was still heard, but notably less marked than before the chest was opened. I infer from this comparison that the bronchi within the solidified lung when *in situ*, the chest unopened, contained more air than when exposed directly to atmospheric pressure. But in this experiment only one of the physical conditions underlying the thoracic voice in life is represented. The production of the voice with the current of air in expiration, and the thoracic respiratory movements are, of course, not included.

Granting that the explanation which has been given of an increased intensity of vocal resonance over solidified lobe or lobes in cases of pneumonia be satisfactory, it remains to endeavor to explain an increased intensity of the thoracic voice when the solidification is not sufficient to give rise to bronchophony; when, for example, in cases of phthisis, the increased resonance of the voice represents a greater or less number of tuberculous nodules. Here it cannot be said, in explanation, that the lung remains permanently expanded, nor that the movements of the chest are notably restricted. The bronchial tubes in the vicinity of the nodules may be dilated, but I am not prepared to state that this is the rule. It is intelligible that these tubes may be prevented from collapsing by the proximity of solidi-

fied nodules. These physical conditions, however, seem hardly adequate to explain the sign. It is still more difficult to explain increase of vocal resonance when portions of lung are partially condensed by the pressure of liquid or an extrinsic tumor. There must be physical conditions involved which, as yet, are not understood. But, I repeat, to accept this conclusion is not to throw a shadow of doubt upon the diagnostic value of increased vocal resonance as a sign of solidification of lung, wherever associated with other signs denoting that condition.

The increase of vocal resonance over cavities is sufficiently intelligible. If a cavity be superficially seated; if it be not surrounded with lung completely or considerably solidified; if it be empty, and there be free communications with unobstructed bronchial tubes, we have a combination of physical conditions favoring the conduction of the voice, so as to give rise to more or less intensity of resonance, with fremitus, but without the modifications of bronchophony. In a lung removed from the body, this combination of physical conditions existing, notable intensity of vocal resonance, as distinct from bronchophony, may be produced by transmitting the voice into the trachea.

It did not occur to Laennec to study the thoracic sounds produced by the whispered voice. Many years ago, impressed with their value, I was led to institute a series of signs derived from this source. The sounds thus produced have, of course, characters corresponding to those belonging to the expiratory act in respiration; but they are brought out in stronger relief, and are better observed, in connection with whispered words. As these signs are correlative to those produced by the loud voice, it seemed appropriate to designate them by corresponding names. Whispering pectoriloquy was a term which had already been used. Applying to the sounds in health the name *normal bronchial whisper*, the morbid signs were named as

follows: *Increased bronchial whisper*, *bronchophonic whisper*, *cavernous whisper*, *whispering pectoriloquy*, and *amphoric whisper*. The differential characters, following the same order in enumeration, are those of the expiratory sounds in broncho-vesicular respiration, bronchial respiration, cavernous respiration, pectoriloquy with the loud voice, and the amphoric voice. It would be superfluous, and therefore tedious, to enter into further description of these signs, and to consider more fully their significance. I would remark, however, that an abnormal increase of the bronchial whisper has often, in my experience, been of much service as one of the signs of incipient phthisis. But with reference to its significance in the diagnosis of that disease, it is essential to take into account the normal points of disparity between the two sides of the chest at the summit. In the infra-clavicular and in the interscapular regions, the normal whisper on the right side is louder than on the left side, but the pitch is a little higher on the left side. Consequently, if the whisper on the left side be louder than that on the right, or even equally loud, it is abnormal; and if the whisper be higher in pitch on the right side, it is abnormal.

Another practical remark relates to whispering pectoriloquy. Here, as with the loud voice, articulated words may be transmitted through solidified lung as well as through a cavity. Here, too, it is not less easy to determine in any instance whether the transmission be through solidified lung or through a cavity. If the pectoriloquy be associated with the characters of the bronchophonic whisper, it is the sign of solidification; but it is the sign of a cavity when associated with the characters of the cavernous whisper, that is, if it be low in pitch and non-tubular in quality.

CONCLUDING REMARKS.

Mr. President and Members of the Philadelphia County Medical Society: In concluding these lectures, I beg to recall the objects which were stated at the outset. I was desirous of showing that Auscultation and Percussion, divested of theories, speculations, non-essential discussions, and needless refinements, may be so simplified as to be made generally available in medical practice. The number of signs obtained by these two methods of physical exploration need not much exceed thirty. In a considerable proportion the characters of these signs are so plainly distinguished, that even their names suffice for a description and their recognition. I desired to show that in order to secure definiteness and clearness as regards the distinctive characters of different signs, and a ready differentiation of them, they must be studied by means of the analytical method. I cannot too strongly express my sense of the importance of relying upon this method of study for our practical knowledge of the signs obtained by auscultation and percussion. I have submitted, as I hope with becoming modesty, the fruits (if I may venture to use that term) of my own studies in this field of medicine for many years—studies relating to the distinctive character of signs, their significance, the introduction of some new signs, and the names by which they are to be designated.

Not ignoring the interest belonging to inquiries concerning the mechanism of the signs, I have entered in these lectures somewhat into a consideration of them in this aspect. My purpose has been chiefly to show that most of the more important of the signs may be produced out of the body, either by simple artificial means, or by using for this end the lungs, healthy and diseased, from the human subject and from inferior animals. The attention which I have of late given to

the experimental illustrations to which I have referred, has led me to appreciate, more than hitherto, their usefulness, not only as explanatory of the mechanism of signs, but as affording valuable aid in teaching practically auscultation and percussion. The production of signs out of the body in the class-room, before bringing students to the bedside for the actual illustrations, must be of much service in facilitating the acquirement of practical knowledge of their distinctive characters, and I commend this exercise to the consideration of instructors in physical exploration.

I need not remind this audience of the inestimable value of the results of the inspired thought which prompted Laennec to improvise a stethoscope by rolling together a few quires of paper. Have these results, after half a century, reached their termination? Is nothing to be expected in the future, in the way of improved means of auscultation? Does the binaural instrument represent the perfection of stethoscopy? I trow not. When we reflect upon the recent development in practical acoustics, as exemplified by the telephone, the microphone, and the phonograph, may we not expect that some inventive genius will develop similar marvels in auscultation? Long before the time of Laennec, a quaint English writer uttered these *quasi* prophetic words: "Who knows but that one may discover the works performed in the several offices and shops of a man's body by the sounds they make, and thereby discover what instrument or engine is out of order." This prediction has been fulfilled. And now, after the manner of Robert Hook, who wrote in 1705, who knows but that the time may come, and perhaps ere long, when the only use of the stethoscope of to-day will be to illustrate, by contrast, an immense improvement in the means of discovering "the works performed in the several offices and shops of a man's body by the sounds they make?"

Treating, as I have done in these lectures, of auscul-

tation and percussion in a purely didactic fashion, I have had to deal with dry topics, which must have been dull to those who have not felt any special interest in the subject. This was unavoidable. The consciousness of the fact enhances the thanks which, under any circumstance, would be due to those who have honored me with their attendance and attention. And in closing, as at the beginning, let me say that I could not adequately express my sense of the honor involved in the invitation to inaugurate a plan of annual lectures which, as I hope, will hereafter be committed to abler hands.